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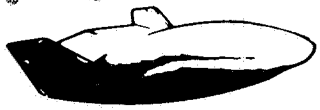

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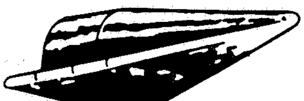

CEI Development Specifications

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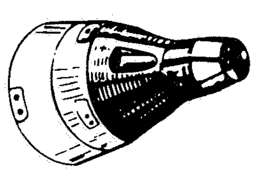
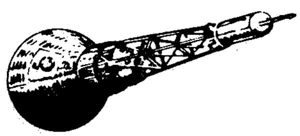
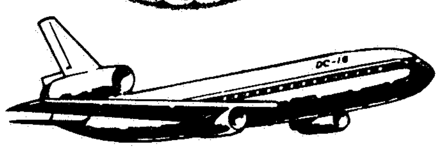




HIGH VALUE

SPACE SHUTTLE



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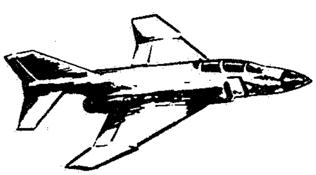

MCDONNELL DOUGLAS CORPORATION

MARTIN MARIETTA DENVER DIVISION

TRW SYSTEMS GROUP

PAN AM

(NASA-CR-143920) CEI DEVELOPMENT SPECIFICATION FOR THE SPACE SHUTTLE ORBITER (McDonnell-Douglas Corp.) 100 p

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SPECIFICATION NUMBER DP255A200

DATE 30 June 1971

PRELIMINARY

CEI DEVELOPMENT SPECIFICATION

FOR THE

SPACE SHUTTLE ORBITER

PREPARED UNDER CONTRACT
NAS8-26016
FOR

NASA

BY

MCDONNELL DOUGLAS CORPORATION
MARTIN MARIETTA DENVER DIVISION
PAN AM
TRW SYSTEMS GROUP

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1. SCOPE. This specification establishes the contractual performance, design and verification requirements for the Orbiter, the payload carrying vehicle to be utilized for low Earth orbit operations in the Space Shuttle Program. The Space Shuttle System is defined in SS255H001.

2. APPLICABLE DOCUMENTS. The following documents of the issue and date indicated shall form a part of this specification to the extent specified herein. In the event of conflict between these documents and the content of Sections 3 and 4 herein, the latter shall take precedence.

2.1 Government Documents.

SPECIFICATIONS:

NASA

SS255H001	System Specification for the Space Shuttle System
DCN 1-0-21-0001	Space Shuttle Main Engine CEI Specification

OTHER PUBLICATIONS:

NASA

CD255I001*	Electromagnetic Interference Control Document for the Space Shuttle Program
CD255V001*	Environmental Requirements Document for the Space Shuttle Program
IF255G600	Booster/Orbiter Interface Control Document for the Space Shuttle Program
IF255G700	Orbiter/Payload Interface Control Document for the Space Shuttle Program

* To be Prepared During Phase C

IF255G800	Space Shuttle/Launch Facility Interface Control Document for the Space Shuttle Program
13M15000	Space Shuttle Vehicle/Engine 550K (SL) Interface Control Document
TM X-53872 15 March 1970	Terrestrial Environment (Climatic) Criteria Guidelines For Use in Space Vehicle Development, 1969 Revision
TM X-53957 17 Oct. 1969	Space Environment Criteria Guidelines For Use in Space Vehicle Development, 1969 Revision

3. REQUIREMENTS.

3.1 Orbiter Definition. The general arrangement of the Orbiter is shown in Figure 1. (Reference only)

3.1.1 Item Diagrams.

3.1.1.1 Functional Schematic. The first level functional schematic of the Orbiter is shown in Figure 2. (Reference only)

3.1.1.2 Functional Flow Diagram. A top level functional flow diagram depicting Orbiter functions in the normal launch-to-launch cycle is shown in Figure 3. (Reference only)

3.1.2 Interface Definitions. The Orbiter shall meet the physical, functional and procedural interfaces defined for the Orbiter in the following ICD's which are incorporated herein by reference:

ICD	Interface
IF255G600	Booster/Orbiter Interface Control Document
IF255G700	Orbiter/Payload Interface Control Document
IF255G800	Shuttle/Launch Facility Interface Control Document
13M15000	Space Shuttle Vehicle/Engine 550K (SL) Interface Control Document

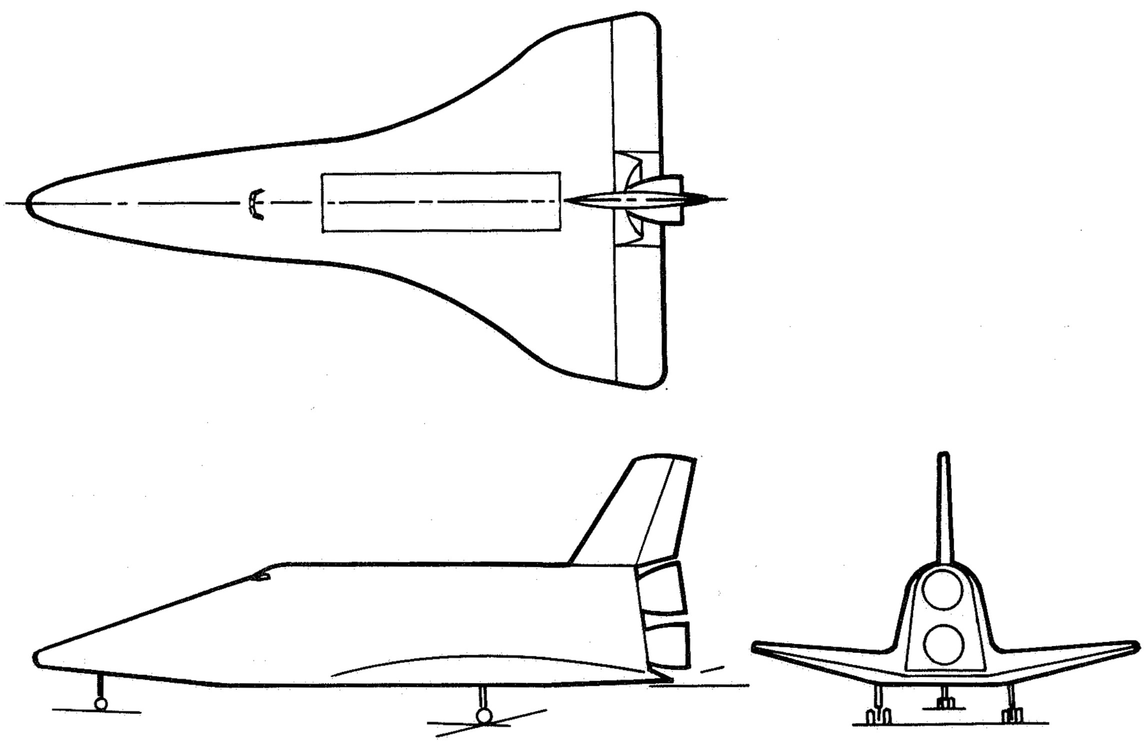


FIGURE 1 ORBITER GENERAL ARRANGEMENT

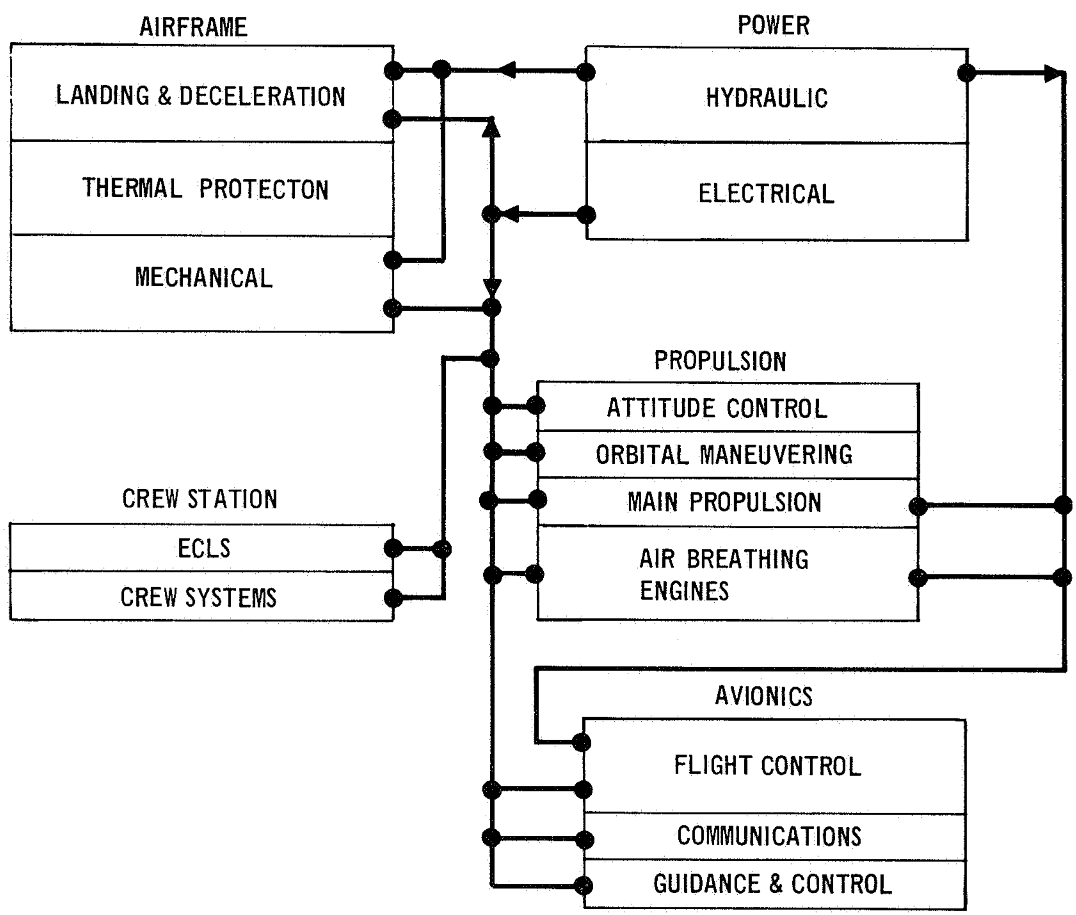


FIGURE 2 FIRST LEVEL FUNCTIONAL SCHEMATIC

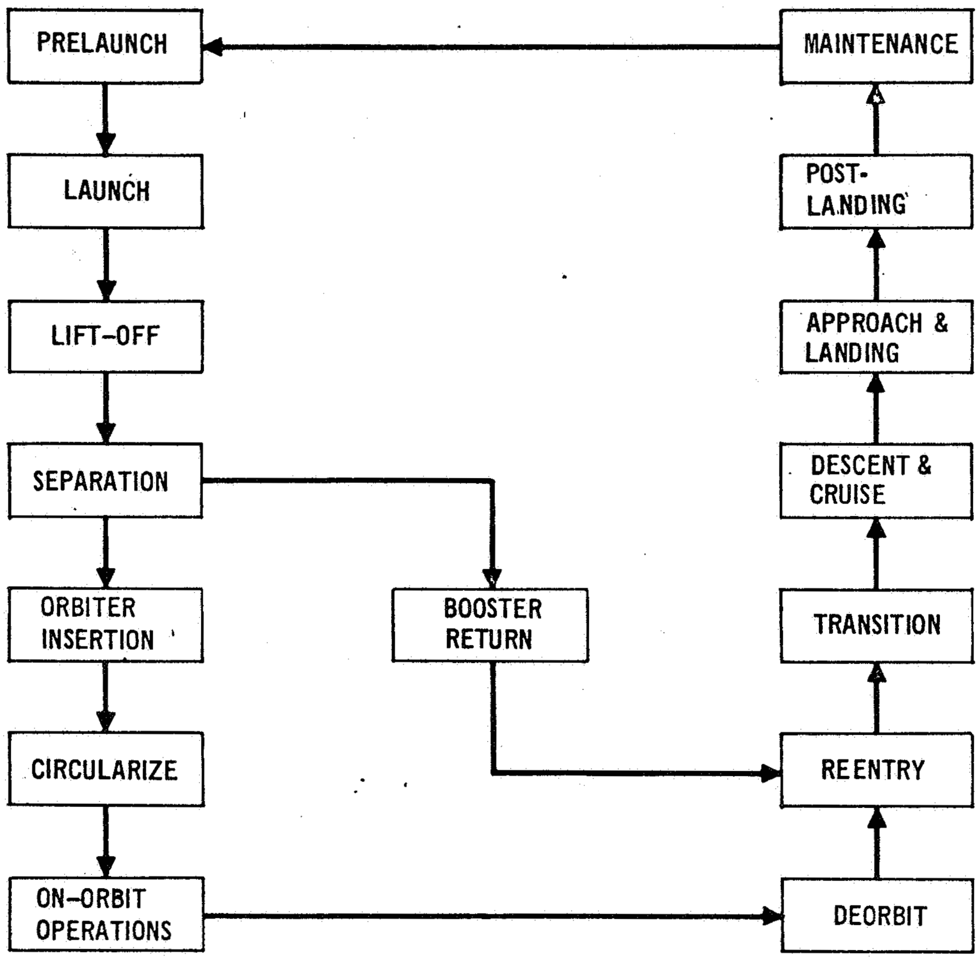


FIGURE 3 MISSION FUNCTIONAL FLOW DIGRAM

3.1.3 Subsystems List. The Orbiter shall include the subsystems shown in Table I.

3.1.4 Government Furnished Equipment List. The following items of Government Furnished Equipment (GFE) will be supplied to the Contractor for incorporation into each Orbiter:

CEI Specification	Quantity	Nomenclature
DCN 1-0-21-0001	2	Main Engine

TABLE I SUBSYSTEM LIST

Airframe Group

A. Structures Subsystem
B. Landing and Deceleration Subsystem
C. Thermal Protection Subsystem
D. Mechanical

Propulsion Group

A. Main Propulsion Subsystem
B. Attitude Control Propulsion Subsystem
C. Airbreathing Propulsion Subsystem
D. Orbit Maneuver Subsystem
E. Auxiliary Power Unit Subsystem

Avionics Group

A. Guidance and Navigation Subsystem
B. Communications and Navigation Aids Subsystem
C. Flight Control Electronics Subsystem
D. Data Management Subsystem
E. Displays and Controls Subsystem

Crew Station Group

A. Environmental Control and Life Support Subsystem
B. Crew Subsystem

Power Supply Group

A. Electrical Power Subsystem
B. Hydraulic Power Subsystem

3.2 Characteristics.

3.2.1 Performance. The Orbiter shall be a reusable manned vehicle capable of transporting payloads into low Earth orbit and returning payloads from orbit to Earth.

3.2.1.1 Mission Requirements And Constraints. The Orbiter shall mate with the Booster for an integrated vertical launch. Propulsion for ascent will be provided by the Booster until the Booster cut-off window is reached and separation is performed, after which, the Orbiter shall provide the required thrust for orbit insertion.

While on orbit, the Orbiter shall be capable of payload deployment and retrieval, rendezvous and docking with the Space Station/Space Base to allow cargo/passenger transfer between the vehicles, rendezvous and docking with other Orbiters for crew rescue, and rendezvous with specified targets.

In returning to Earth, the Orbiter shall perform reentry and atmospheric flight to effect a horizontal landing on runways.

After refurbishment, the vehicle shall be suitable for reuse on subsequent missions for a total of 100 flights. The intended combined storage and operational service life is 10 years after initiation of operational capability (IOC).

3.2.1.1.1 Design Mission. The Space Shuttle design mission shall be defined as follows:

A. Design orbit - 100 NM due East circular orbit.

B. Insertion orbit - 50 x 100 NM

C. Payload delivered - 65,000 lbs with Orbiter airbreathing engines removed.

D. Payload returned - 0 to 40,000 lbs with Orbiter airbreathing engine removed - larger payloads up to 65,000 lbs with reduced safety factors.

E. Mission duration - 7 days of self-sustaining lifetime.

F. Launch site - 28.5 degrees launch latitude.

3.2.1.1.2 Reference Missions. Two reference missions of major interest are defined as follows:

A. South polar -

(1) Design orbit - 100 NM South polar circular orbit

(2) Insertion orbit - 50 x 100 NM

(3) Payload delivered - 40,000 lbs with Orbiter airbreathing engines removed and OMS tanks filled.

(4) Payload returned - 0 to 40,000 lbs with Orbiter airbreathing engines removed

(5) Mission duration - 7 days of self-sustaining lifetime

(6) Launch site - 28.5 degrees launch latitude.

B. Resupply -

(1) Design orbit - 270 NM orbit at 55° inclination

(2) Insertion orbit - 50 x 100 NM

(3) Payload delivered - 25,000 lbs with Orbiter airbreathing engines installed

(4) Payload returned - 0 to 25,000 lbs with Orbiter airbreathing engines installed

(5) Mission duration - 7 days of self-sustaining lifetime

(6) Launch site - 28.5 degrees launch latitude

3.2.1.1.3 Mission Profile. Mission profiles for the design and reference missions are shown in Figures 4, 5, and 6.

3.2.1.1.4 Rescue Operations. The Orbiter shall be capable of performing rescue operations for an Orbiter, Space Station, or Space Base in the resupply reference orbit within 48 hours after notification. Rescue is considered complete when the personnel transfer is accomplished and the Orbiter has separated from the other vehicle.

3.2.1.1.5 Extended Mission Duration. The Orbiter shall be capable of being modified to perform missions with durations up to 30 days. Additional propellants and other provisions required may be installed in the payload area and will be charged against payload weight.

3.2.1.2 Mission Phase Characteristics.

3.2.1.2.1 Prelaunch Phase. The Prelaunch Phase consists of the activities in the assembly building and includes subsystem

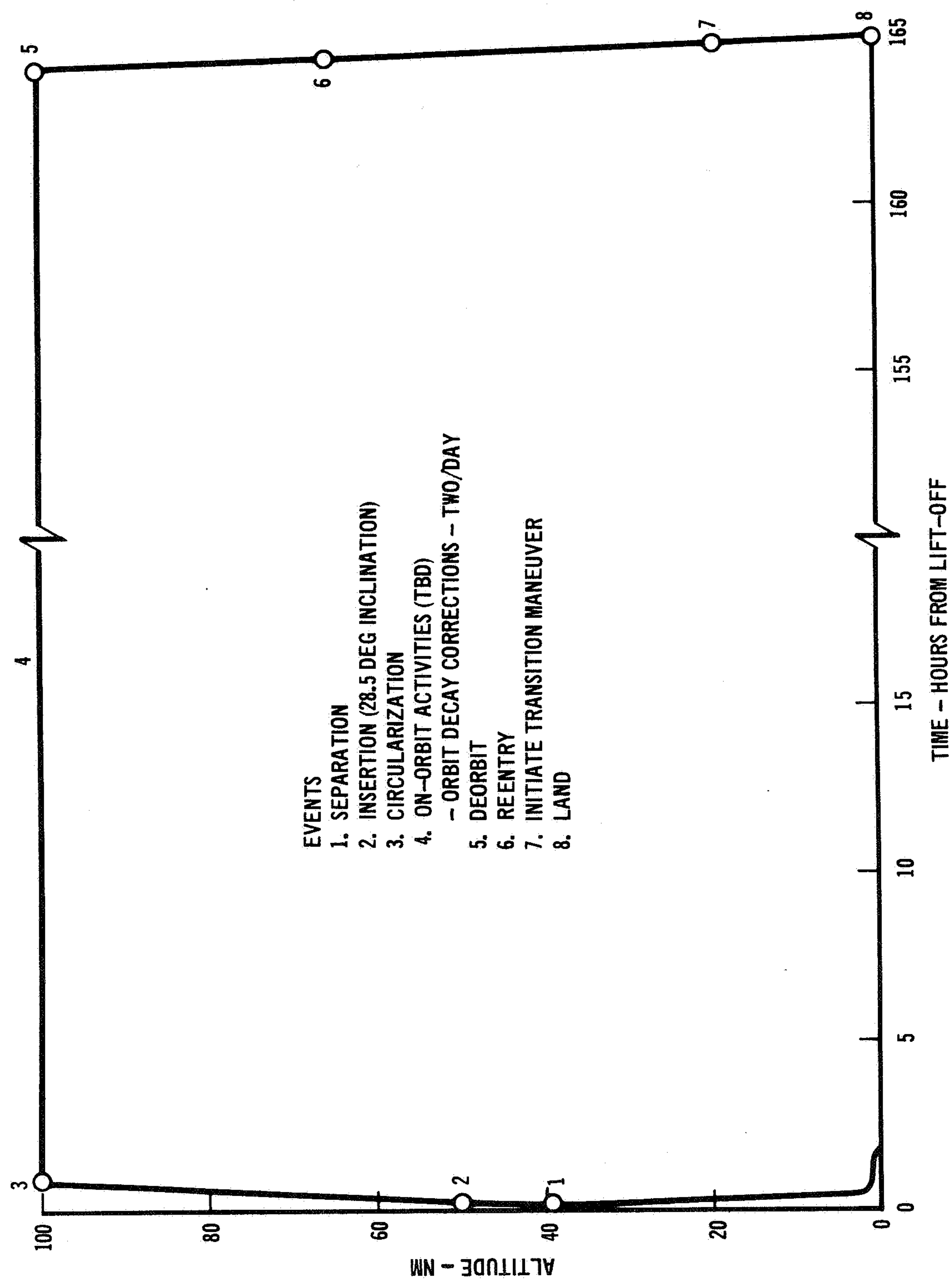


FIGURE 4 DESIGN MISSION PROFILE

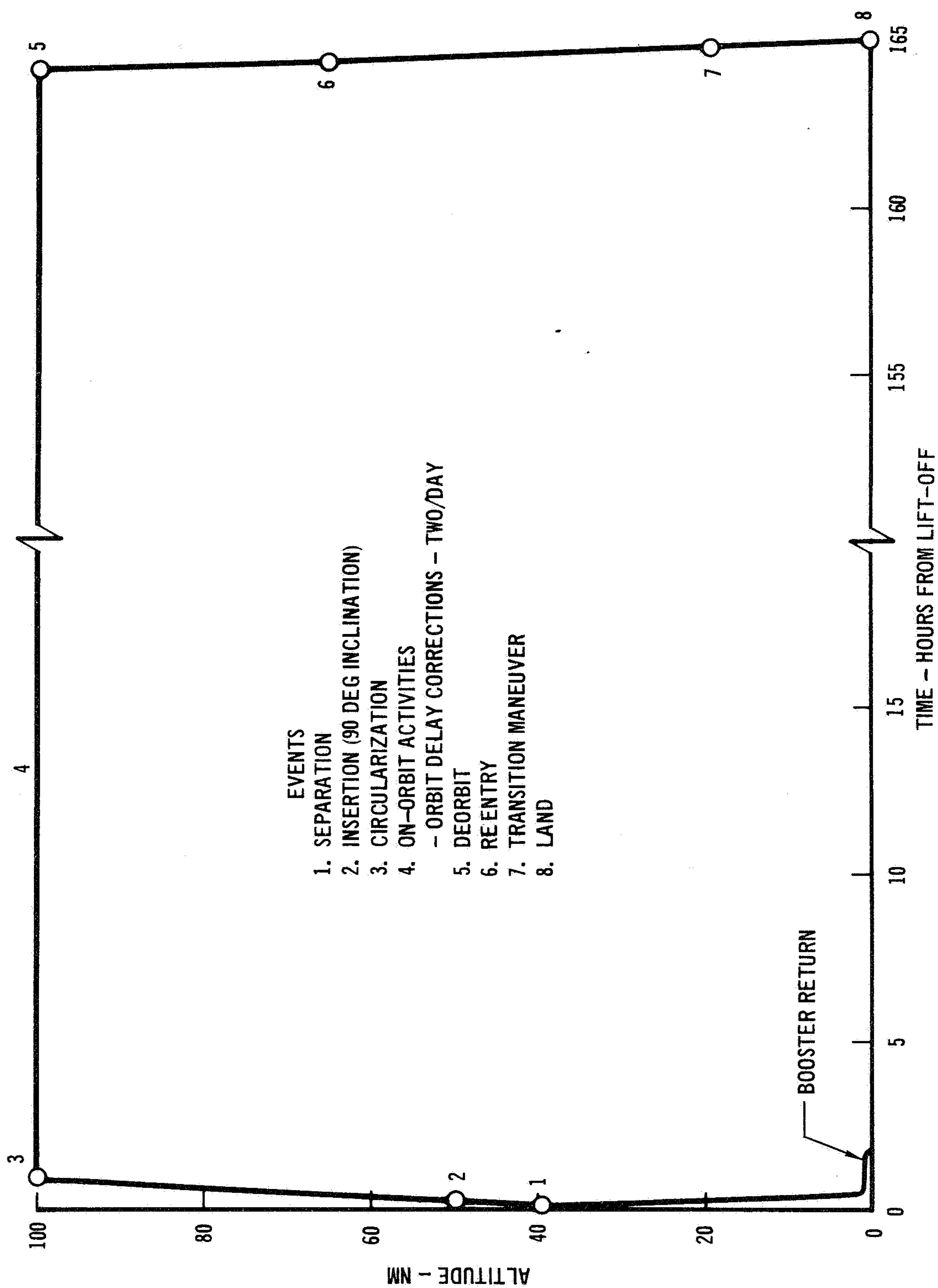


FIGURE 5 SOUTH POLAR REFERENCE MISSION PROFILE

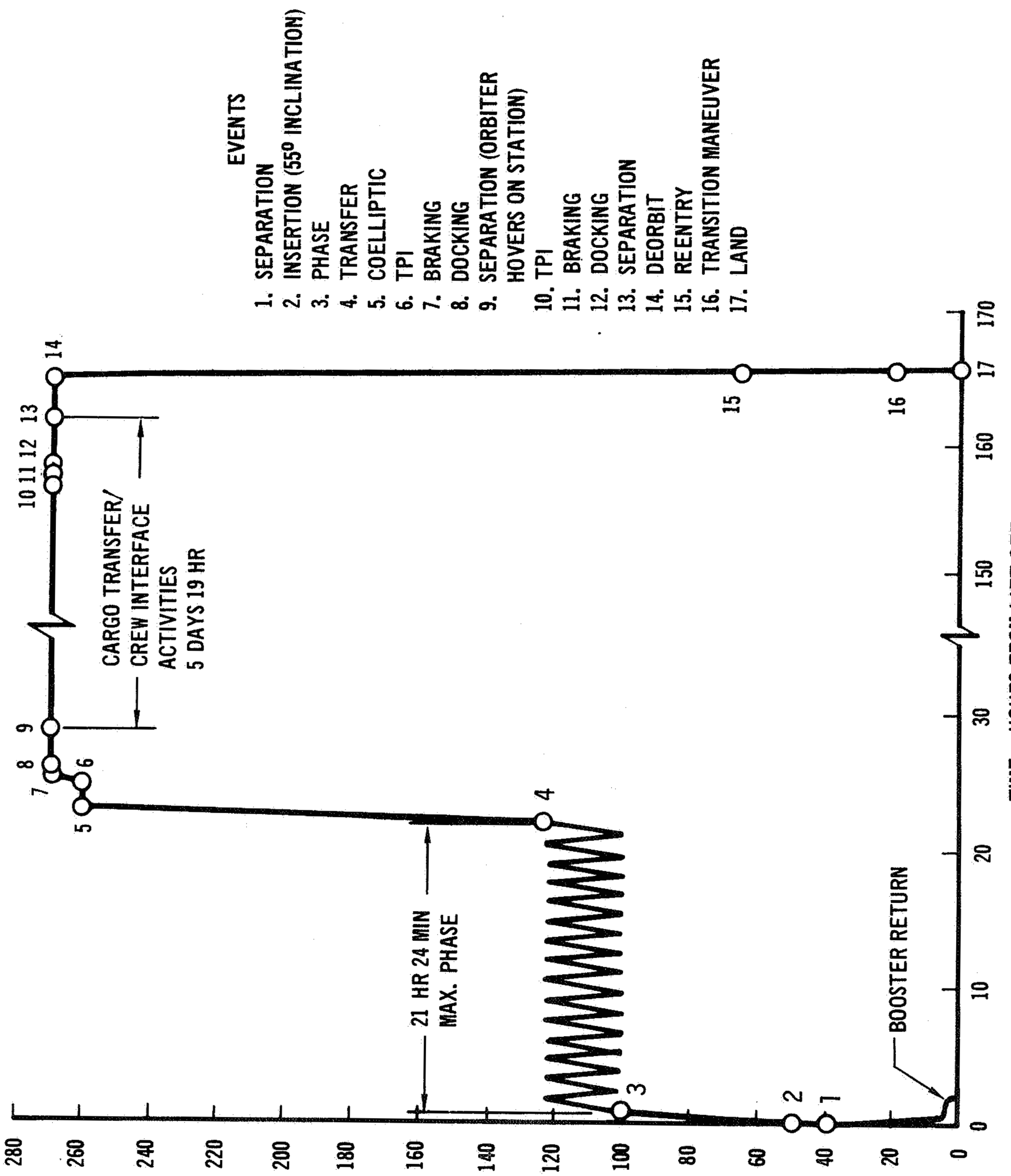


FIGURE 6 RESUPPLY REFERENCE MISSION PROFILE

checkout, payload integration mate, Booster mate, and combined system checkout. The Orbiter shall be compatible with checkout in both a mated and unmated configuration.

3.2.1.2.1.1 Vehicle Mating. The Orbiter shall mate with the Booster as shown in Figure 7. Capability for horizontal as well as vertical mating shall be provided. Attachment details and dimensions shall be as specified in IF255G600.

3.2.1.2.2 Launch Phase. The Launch Phase begins with moving the erected/mated Space Shuttle to the launch pad and concludes with liftoff. Orbiter functional interfaces with ground equipment/facilities required after ignition shall be separated as a direct result of vehicle motion. Umbilical couplings and electrical connectors, when grouped into one common assembly, shall not contain individual locking mechanisms.

3.2.1.2.2.1 Launch Azimuth. The Orbiter shall provide an all azimuth launch capability. The vehicle shall be designed to launch on time for all azimuths.

3.2.1.2.2.2 Launch From a Standby Status. The Orbiter shall be ready for launch from a standby status within 2.5 hours of a mission proceed decision and shall be ready for Space Shuttle liftoff within a 60-second launch window.

3.2.1.2.2.3 Hold Capability. The Orbiter shall be capable of holding in a ready-to-launch condition for a period up to ten (10) hours.

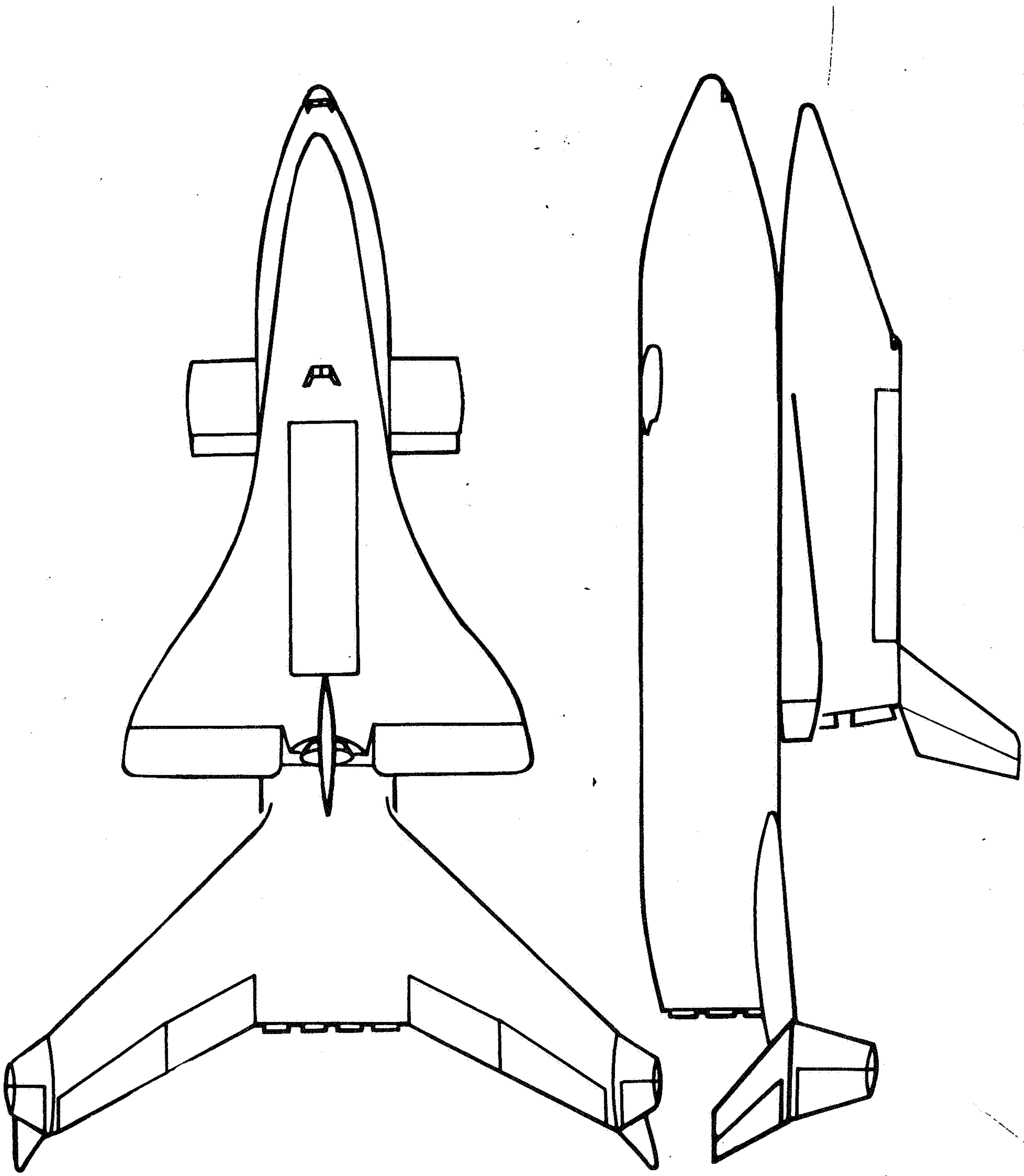


FIGURE 7 BOOSTER/ORBITER MATED CONFIGURATION

3.2.1.2.2.4 Launch Phasing. The Orbiter shall provide launch phasing capability for day and night rendezvous and docking with the Space Station or Space Base.

3.2.1.2.2.5 On-Pad Abort. The Orbiter shall provide safe mission termination capability including rapid crew egress prior to liftoff.

3.2.1.2.3 Ascent Phase. The ascent phase begins with liftoff and ends with successful insertion into orbit and includes intermediate abort operations in the event of premature termination of the ascent flight phase. During the Booster flight portion (preseparation), the Orbiter shall be in a ready status but shall not provide any function in conduct of the total vehicle boost performance.

3.2.1.2.3.1 Trajectory. The ascent trajectory shall be controlled to limit load factors to a level less than 3.0 g.

3.2.1.2.3.2 Booster Cut-Off Window. To achieve the desired orbit, the Orbiter will be placed in the required window by the Booster. For the design and reference missions, the Booster cut-off window will be:

Mission	Relative Velocity	Flight Path Angle	Altitude
Easterly	10,800 ± TBD fps	8.2 ± TBD°	209,200 ± TBD ft.
Polar	11,000 ± TBD fps	7.8 ± TBD°	213,200 ± TBD ft.
Resupply	10,900 ± TBD fps	8.0 ± TBD°	211,240 ± TBD ft.

3.2.1.2.3.3 Separation. The Booster will provide a separation impulse sufficient to allow safe vehicle separation and clearance and allow Orbiter main engine ignition within TBD seconds. The separation signal will normally be generated by the Booster; the Orbiter shall be capable of sending a backup separation signal.

3.2.1.2.3.4 Orbit Insertion Window. The Orbiter shall provide the required thrust, steering and control, following separation, to place the Orbiter in the following insertion windows (perigee injection):

Mission	Inertial Velocity	Flight Path Angle	Altitude
Easterly	25,900 ± TBD fps	0 ± TBD°	50 ± TBD NM
Polar	25,900 ± TBD fps	0 ± TBD°	50 ± TBD NM
Resupply	25,900 ± TBD fps	0 ± TBD°	50 ± TBD NM

3.2.1.2.3.5 Ascent Abort. The Orbiter shall provide an intact abort capability. Intact abort is defined as the capability of the Booster and Orbiter to separate and continue flight to a safe landing; the Orbiter to land with a full payload.

In the event of an Orbiter main engine failure after achieving the Booster cut-off conditions, the Orbiter shall be capable of achieving a once-around orbit to a safe landing.

3.2.1.2.4 On-Orbit Phase. The on-orbit phase follows insertion into orbit and extends to initiation of retrograde.

3.2.1.2.4.1 Orbiter Delta Velocity. The Orbiter shall have sufficient propellant to provide the following on-orbit delta velocity capability in excess of the amount required to attain the designated insertion orbit with the specified payload weights:

Mission	Delta Velocity (ΔV) Minimum
Easterly	900 fps
Polar	650 fps
Resupply	1500 fps

Orbiter tanks shall be sized to provide 2000 fps delta velocity capability for the resupply mission.

3.2.1.2.4.2 Payload Deployment And Retrieval. The Orbiter shall be capable of deploying and retrieving payloads as specified in IF255G700.

3.2.1.2.4.3 Rendezvous. The Orbiter shall be capable of rendezvous with cooperative targets (targets having a ranging beacon transponder compatible with the Orbiter rendezvous ranging system) and, by using target ephemeris provided by ground facilities and other aids as appropriate, shall be capable of rendezvous with a passive (no transponder) target. The three (3) sigma accuracy requirements for the target ephemeris are as follows (expressed in a local vertical coordinate system):

Component	Position (ft)	Velocity (fps)
Radial	500	.5
Tangential	800	.5
Normal	100	1.0

Nodal Period = 0.1 sec

Epoch Time = 0.05 sec

Aids other than those provided for cooperative target rendezvous will be provided within the payload.

3.2.1.2.4.4 Docking. The Orbiter shall be designed for the following docking contact conditions between the Orbiter payload and Space Station or Space Base:

Centerline Miss Distance	±6 inches
Miss Angle (including roll)	±3 degrees
Longitudinal Velocity	0.4 ft/sec
Lateral Velocity	0.15 ft/sec
Angular Velocity	0.1 deg/sec

3.2.1.2.4.5 Stationkeeping. The Orbiter shall provide a stationkeeping capability for cooperative targets.

3.2.1.2.4.6 EVA Activities. The Orbiter design shall not preclude extra vehicular activity (EVA) capability, but provisions for EVA will be provided at the expense of the allocated payload weight.

3.2.1.2.5 Reentry Phase. The reentry phase begins with the initiation of the retrograde command and ends when cruise attitude and altitude is achieved. The Orbiter shall be designed for automated reentry into the Earth's atmosphere with manual control as a back-up mode. The Orbiter shall be capable of returning to suitable CONUS landing sites at least once every 24 hours.

3.2.1.2.5.1 Cross-Range. The Orbiter shall provide a nominal aerodynamic cross-range capability of 1100 nautical miles. Cross-range is defined as the normal distance along a great circle from the orbital ground track to the landing site.

3.2.1.2.5.2 Acceleration Limits. The Orbiter trajectory shall be controlled during reentry to limit load factors to a level less than 3.0 g.

3.2.1.2.6 Approach And Landing Phase. The approach and landing phase includes the transition maneuver and extends until completion of touchdown and roll-out operations. When airbreathing engines are installed for operational missions, the Orbiter shall be capable of maintaining level flight with one engine out at an altitude of 7000 feet.

3.2.1.2.6.1 Handling Qualities. Landing characteristics and handling qualities of the Orbiter shall as a design objective not require skills more demanding than those required for operational land-based aircraft.

3.2.1.2.6.2 Go-Around. The Orbiter shall be capable of performing a go-around maneuver initiated at 1000 feet above the landing site elevation with one airbreathing engine out and the Orbiter in the approach configuration. With all airbreathing engines operating and the Orbiter in the landing configuration, the Orbiter shall be capable of performing a go-around maneuver initiated 200 feet above the landing site elevation.

3.2.1.2.6.3 Propellant Depletion. For normal mission operations the Orbiter shall be capable of depleting the propellants in the main propulsion tanks prior to landing. The capability to dump excess attitude control and orbit maneuver propellants shall also be provided.

3.2.1.2.6.4 Landing Requirements. The Orbiter shall be capable of performing horizontal landings on runways 10,000 feet in length at sea level on a hot day (95 percentile maximum temperature at KSC) per FAA wet field conditions, with payload weights specified for the design and reference missions. The Orbiter shall provide an automatic landing capability under FAA Cotegory II conditions and a pilot controlled backup landing capability with at least 1000 feet ceiling and one mile visibility.

3.2.1.2.7 Post-Landing Phase. The post-landing phase consists of the activities following touchdown and roll-out of the vehicle and concludes with moving of the vehicle into the maintenance area.

3.2.1.2.7.1 Post-Landing Crew Egress. The Orbiter shall incorporate provisions to permit unaided crew and passenger emergency egress. Normal crew egress will be accomplished utilizing GSE.

3.2.1.2.7.2 Taxi. The Orbiter, when airbreathing engines are installed, shall provide taxi capabilities for vehicle movement to and from runways. The vehicle shall be capable of being towed with and without airbreathing engines installed.

3.2.1.2.8 Turn-Around. The nominal Orbiter turn-around time from landing at the launch site to launch readiness shall not exceed two (2) weeks. The removal and replacement time shall be minimized with on-board checkout and module accessibility.

3.2.1.2.9 Ferry Flights. The Orbiter, utilizing airbreathing engines and auxiliary tankage as required, shall be capable of low altitude ferry flights under daylight VFR conditions for a minimum range of 450 nautical miles. Rocket assist devices may also be utilized. The Orbiter shall be flyable by one crewman in emergency conditions.

3.2.2 Physical Characteristics.

3.2.2.1 Mass Properties. The Orbiter mass properties limits shall be as specified in Table II. Payload and main engine mass properties limits will be as specified in IF255G700 and 13M15000.

3.2.2.2 Dimensional Requirements. Dimensional limitations with the interfacing elements (Booster, payload and main engines) are as specified in IF255G600, IF255G700, and 13M15000.

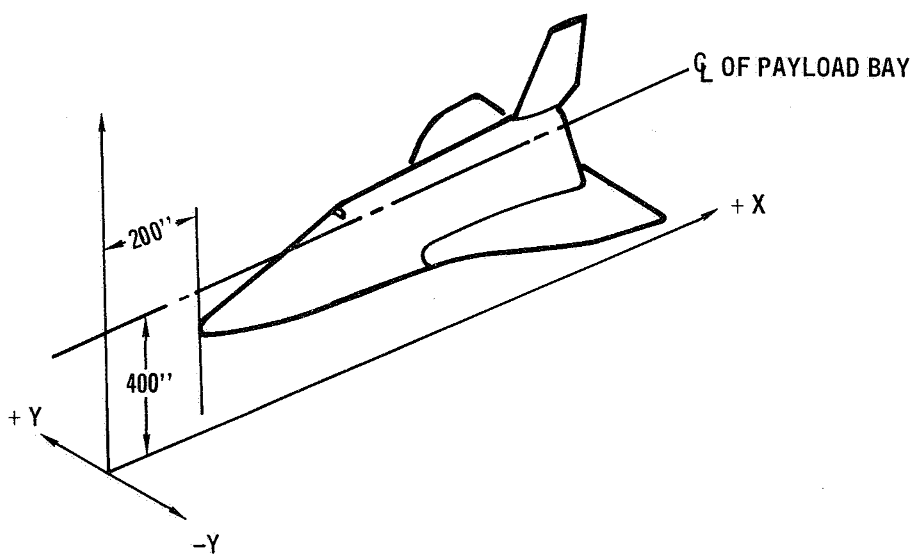
3.2.3 Reliability.

3.2.3.1 Failure Criteria. Avionic systems, with the exception of the following items, shall be designed to fail-operational after failure of the two most critical components and to fail-safe for crew survival after a third failure:

TABLE II ORBITER MASS PROPERTIES LIMITS

ITEM		LAUNCH CONDITION	INJECTION CONDITION	ENTRY CONDITION	LANDING CONDITION	FERRY CONDITION
WEIGHT	– MAXIMUM	TBD	TBD	TBD	TBD	TBD
	– MINIMUM	↓	↓	↓	↓	
X_{CG}	– FORWARD	1052	1456	1453	1449	
	– AFT	1081	1509	1498	1495	
Y_{CG}	– LEFT	–0.5	–1.3	–1.4	–1.5	
	– RIGHT	0.5	+1.3	+1.4	1.5	
Z_{CG}	– UP	255	301	301	298	
	–DOWN	242	269	268	258	
I_{ROLL}	– MAXIMUM	TBD	TBD	TBD	TBD	
	– MINIMUM					
I_{PITCH}	– MAXIMUM					
	– MINIMUM					
I_{YAW}	– MAXIMUM	↓	↓	↓	↓	↓
	– MINIMUM	TBD	TBD	TBD	TBD	TBD

ALL CG'S ARE IN INCHES FROM REFERENCE AXIS BELOW



A. Data buses and digital interface units shall have the same redundancy as the units served.

B. Landing aids, rendezvous sensors, and communications shall be designed to fail-operational after failure of the two most critical components.

The following subsystems and items shall be exempt from the fail-safe criteria, but be appropriately designed for the necessary reliable operation:

A. Structure

B. Landing gear

C. Main propulsion

D. Main propulsion feed lines

E. Pressure vessels

F. Passive thermal protection

G. Interior insulation

H. Electro-explosive devices

I. Drag chutes

J. Main gear wheel brakes

K. Gear-up actuation

L. Gas and fluid lines for main propulsion, orbit maneuver subsystem, attitude control propulsion subsystem, auxiliary power units, airbreathing engine subsystem, environmental control and life support subsystem, and brakes.

All other subsystems shall be designed to fail operational after the failure of the most critical component and to fail safe for crew survival after the second failure.

The term "operational" as used above means that the vehicle has the capability for safe mission completion, with the full degree of performance provided in the design. Temporary departure from desired performance shall be correctable without significant degradation of mission results.

The term "safe" as used above means that the vehicle and crew shall be able to return to a landing site without fatality or serious injury to crew or passengers. Degraded operation is acceptable.

3.2.3.2 Redundancy. In systems where redundancy is needed, the vehicle systems shall be developed to provide redundant full mission capability and shall avoid, where possible, minimum requirement, minimum performance backup system concepts. Redundant paths, such as fluid lines, electrical wiring, connectors, and explosive trains shall be located where practical, to insure that an event which damages one line is not likely to damage the other. Redundant systems shall provide the following characteristics:

A. Loss of redundancy shall be detectable.

B. The capability to verify redundant operation prior to launch shall be provided.

3.2.4 Maintainability. Maintainability for the Orbiter shall be consistant with the two week turnaround operations. Access shall be such that malfunctioning Line Replaceable Units (LRU's) may be maintained or replaced during ground operation. Subsystems shall be designed for ease of removal and replacement to the lowest replaceable modular level, making maximum use of airline practice. Human engineering design for access, maintenance and LRU replacement shall be in general accordance with MIL-STD-1472. The Orbiter systems shall facilitate on-condition maintenance. On-condition maintenance is defined as continued operation without overhaul until an observed or predicted condition indicates that deterioration leading to possible failure is about to occur.

3.2.4.1 Maintainability Cycle. The nominal maintenance cycle per Orbiter shall be to five days. The maintenance cycle starts with vehicle landing and ends at the prelaunch phase.

3.2.4.2 Maintenance Manhour Rate. As a design objective, the maximum maintenance manhours required per maintenance cycle for Level I maintenance shall be 1770 manhours. Level I maintenance is defined as all maintenance accomplished directly on system installed hardware including:

A. Fault isolation to the LRU
B. LRU removal and replacement or repair-in-place, servicing and inspection.

C. Any maintenance performed on the vehicle in the launch configuration (limited to corrective maintenance).

3.2.4.3 Maintenance Complexity. The Orbiter shall be designed for Level I maintenance. As a design objective, Level I maintenance shall be accomplished by the following personnel after the 25th flight (based on a 90% progress curve).

A. 40 Helpers

B. 23 Journeymen

C. 10 Masters

3.2.4.4 Inflight Maintenance. In general, there shall be no requirement for inflight maintenance.

3.2.5 Environmental Conditions.

3.2.5.1 Natural. The Orbiter design for natural environments shall utilize TM X-53872 and TM X-53957 as guidelines for terrestrial and space environments, respectively.

3.2.5.2 Induced. Orbiter equipment shall be designed to withstand the induced environments specified in CD255V001.

3.2.6 Transportability. The Orbiter shall be capable of ferry flights as defined in 3.2.1.2.9. Orbiter assemblies shall be designed for transportation in an as-near-assembled form as practicable.

Provisions for handling large assemblies as well as the complete Orbiter shall be consistent with handling and transportation procedures.

3.2.7 Commonality. Hardware will be designed to permit commonality of systems, subsystem components and parts between the Orbiter and other program elements. The Orbiter portion of the Booster/Orbiter interface shall be such that any two Orbiters will be interchangeable.

3.3 Design and Construction.

3.3.1 Materials, Processes and Parts. Materials, processes and parts shall be selected with attention given to the stringent requirements of temperature gradients, thermal conductivity, toxic contamination potential in crew atmospheric environments, vibration, shock, loads, pressure, lightweight construction, and simplicity of manufacture. Existing manned-flight qualified components and parts shall be used when the items fulfill the desired performance criteria.

The use of nonmetallic materials contributing towards the toxic contaminants of the pressurized crew compartment shall be controlled. All crew compartment nonmetallic materials shall be selected from the previously qualified nonmetallic materials listed in TBD to assure that odor, off-gassing, and flammability properties are acceptable.

3.3.1.1 Standard and Commercial Parts. Military Standard (MS), Army-Navy (AN), National Aerospace Standard (NAS), and MSFC Standard parts shall be identified by their standard part numbers. Commercial parts shall be qualified for the intended use.

3.3.1.2 Moisture and Fungus Resistance. Except as otherwise required by detail design considerations, only materials which resist the corrosive action of salt air and damage from moisture and fungus shall be used. Suitable protective coatings may be used which will not lose their protective characteristics during the normal course of inspection, maintenance, and testing operations.

3.3.1.3 Corrosion of Metal Parts.

3.3.1.3.1 Stress Corrosion. Materials, parts finishes and processes shall be employed that minimize sustained/residual surface tensile stresses, stress concentrations and the hazards of stress corrosion cracking and hydrogen embrittlement. Metals shall be evaluated for stress corrosion per the design guidelines in TBD.

3.3.1.3.2 Dissimilar Metals. Dissimilar metals as defined in TBD, which are subject to electrolytic corrosion, shall not be used in combination unless suitably coated or separated by barrier material compatible with both metals.

3.3.1.3.3 Protective Methods. Protective methods and materials for cleaning, surface treatment, and application of finishes and protective coatings shall be in accordance with the requirements of TBD. Finishes shall be selected to meet overall system performance requirements.

3.3.1.4 Materials Compatibility. Materials and surfaces which may be exposed to contact with the service media shall be selected for compatibility with these media. Material compatibility requirements with liquid oxygen (LOX) and gaseous oxygen (GOX) shall be per TBD.

3.3.1.5 Contamination Control. Contamination of LOX components and other contamination sensitive components shall be maintained within acceptable limits through use of positive controls.

3.3.2 Electromagnetic Radiation. The Orbiter shall be designed to the requirements specified in CD255I001.

3.3.3 Nameplates and Product Marking. Requirements for equipment identification plates and special markings and labels shall be in general accordance with TBD.

3.3.4 Workmanship. The Orbiter shall be fabricated, assembled, and finished in accordance with applicable contractor standards and process specifications. Particular attention shall be given to quality and thoroughness of soldering, crimping, wiring, marking of parts and assemblies, plating, painting, riveting, machine screw assemblage, welding, brazing, freedom of parts from burrs, sharp edges and debris.

3.3.5 Interchangeability. Mechanical and electrical interchangeability shall exist between like assemblies, subassemblies, and replaceable parts of operating subsystems regardless of the manufacturer or supplier. Nonoperating subsystems such as structure need not comply with this requirement. Interchangeability, for the purpose of this paragraph, does not mean identical, but requires that a substitution of such like assemblies, subassemblies, and replaceable parts be easily effected without physical or electrical modifications to any part of the equipment or assemblies, including cabling, connectors, wiring, and mounting, and without resorting to selection. All components which have the same part number, regardless of the source, shall be functionally and dimensionally interchangeable.

3.3.6 Safety.

3.3.6.1 Intervehicle Damage Propagation. A failure of the Orbiter, other than a failure imposing a major dynamic force, or combinations of such forces, such as over-pressure, excessive heat, or excessive acceleration, shall not degrade the operating capability of the Booster below its "fail safe" level.

3.3.6.2 Critical System Malfunctions. All components associated with enabling the crew to recognize and correct critical systems malfunctions shall be functionally independent of ground support and external interfaces. Automated critical control functions shall provide for crew-initiated override/interrupt capability.

3.3.6.3 Hazardous/Emergency Warnings. Hazardous/emergency condition warnings (not including caution and warning) originating within the Orbiter while mated to the Booster shall be presented immediately to the Booster for simultaneous crew alert. Hazardous/emergency warnings received from the Booster shall be displayed immediately to the Orbiter crew.

3.3.6.4 Engine Shutdown. Orbiter propulsion systems shall be capable of safe shutdown at any time.

3.3.6.5 Electrical Potential. The Orbiter shall incorporate a means of discharging electrical potential differences between the Orbiter and Booster.

3.3.6.6 Safety Provisions After Landing. The Orbiter shall incorporate on-board provisions to readily place the vehicle in a safe condition following landing.

3.3.7 Human Performance. The design of the flight vehicle. elements shall consider ease of operation, maintenance, monitoring, servicing, and handling within normal human capabilities of muscular exertion, visual perception, and physical dexterity. Requirements of access, tool clearance, tubing and wiring routing, and connector identification shall be considered. Equipment design shall minimize the need for special tools or procedures. All crew activities shall be time-phased with other crew tasks and shall recognize the limitations in mobility and dexterity imposed by the vehicle cabin. The Orbiter shall be flyable under emergency conditions by a single crewman.

3.4 Documentation. The relationship of this document to other program documents shall be as depicted in Figure 8.

3.5 Logistics. N/A

3.6 Personnel And Training. N/A

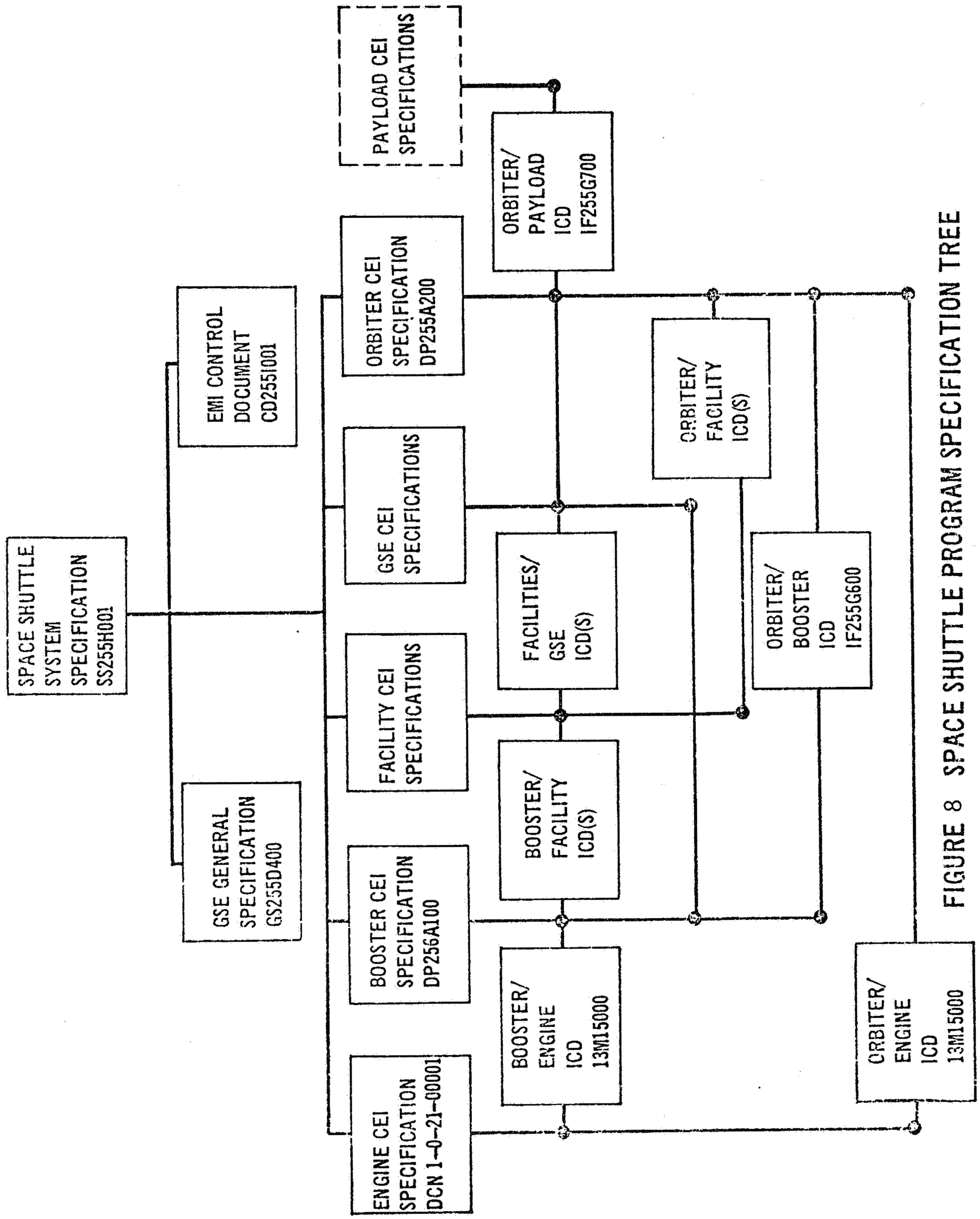


FIGURE 8 SPACE SHUTTLE PROGRAM SPECIFICATION TREE

3.7 Subsystem Characteristics.

3.7.1 Airframe Group. The Orbiter airframe group shall be designed to the requirements specified in Table III.

3.7.1.1 Structural Subsystem. In addition to the requirements in Table III, the Orbiter structure shall be designed to allow Booster mating with the Booster in a horizontal position as well as in a vertical position.

3.7.1.2 Landing And Deceleration Subsystem. The landing and deceleration subsystem shall provide for horizontal landing and stopping, taxiing, ground control, and ferry flight takeoff.

3.7.1.2.1 SAC Base Runways. The landing subsystem shall permit takeoff and landings on SAC base runways. The sub-system shall be capable of limited operations on alternate airfield runways.

3.7.1.2.2 Deceleration. Deceleration shall be provided by wheel brakes and a drag parachute to permit landing on runways specified in 3.2.1.2.6.4.

3.7.1.2.3 Runway Operation. Nose gear steering, wheel brakes and/or aerodynamic controls shall provide the required directional stability and control necessary for runway operation.

TABLE III STRUCTURAL DESIGN REQUIREMENTS

- DESIGN FACTORS
  FACTOR OF SAFETY = 1.4
- DESIGN HEATING EFFECTS
  THE TOTAL HEAT REQUIREMENT SHALL BE BASED ON NOMINAL TRAJECTORIES WITH THE RESULTING HEAT TRANSFER COEFFICIENTS MULTIPLIED BY THE APPROPRIATE THERMAL DESIGN FACTOR. HEATING EFFECTS FOR ITEMS NOT DESIGNED BY THE TOTAL HEAT REQUIREMENTS SHALL BE DETERMINED BY MULTIPLYING THE HEAT TRANSFER COEFFICIENTS, RESULTING FROM DESIGN (DISPERSED) TRAJECTORIES, BY THE APPROPRIATE THERMAL DESIGN FACTOR.

THERMAL DESIGN FACTORS

BASIS FOR HEATING RATE DETERMINATION	DESIGN FACTOR
• THEORETICAL	TBD
• TEST DATA (USE AVERAGE FAIRING)	TBD

- NATURAL ENVIRONMENTS
  GROUND WINDS: 99% PROBABILITY
  LAUNCH AND ASCENT WINDS: 95% PROBABILITY
  DESIGN ATMOSPHERES
  ASCENT: CAPE KENNEDY REF ATMOSPHERE PER NASA TM-X-53872
  ENTRY: U.S. STANDARD ATMOSPHERE – 1962
- LOAD FACTORS
  ASCENT: 3.0 LONGITUDINAL
  AIRPLANE: +2.5, –1.0 NORMAL
- DESIGN SINK SPEED AT TOUCHDOWN = 10 FPS
- PRESSURIZATION
  THE FOLLOWING PROOF AND BURST FACTORS SHALL BE APPLIED TO THE MAXIMUM EXPECTED OPERATING PRESSURE (MEOP) OF VARIOUS COMPONENTS. IN ADDITION TO THESE FACTORS, WHEN ADEQUATE FRACTURE TOUGHNESS DATA AND SUFFICIENT KNOWLEDGE OF OPERATING CONDITIONS ARE AVAILABLE, FRACTURE MECHANICS PRINCIPLES CAN BE USED TO DETERMINE THE REQUIRED PROOF PRESSURE. THE REQUIRED PROOF AND ALLOWABLE OPERATING STRESSES WILL BE DETERMINED AND USED WHEN APPROVED BY THE NASA.

TYPE OF VESSEL	PROOF FACTOR	BURST FACTOR	REMARKS
MAIN PROPELLANT TANKS	1.05	1.4	YIELD FACTOR = 1.1
PERSONNEL COMPARTMENTS	1.5	2.0	
WINDOWS, DOORS AND HATCHES	2.0	3.0	
PNEUMATIC, HYDRAULIC AND HIGH PRESSURE VESSEL SYSTEMS	1.5	2.0	

3.7.1.2.4 Landing Gear Operation. The landing gear shall be retractable and provide latching mechanisms for both retracted and extended positions.

3.7.1.3 Thermal Protection Subsystem (TPS). The TPS shall consist of a system of removable heat shields designed to protect the vehicle structure and vehicle contents from damage resulting from heating. The TPS shall be designed with consideration for cumulative damage resulting from repeated service and shall be readily replaceable without damage to adjacent parts of the TPS. The TPS design shall consider the effects of creep, fatigue, and material property degradation.

3.7.1.4 Mechanical Subsystem. The mechanical subsystem shall provide the mechanical equipment required for payload accommodations, structural mating with the Booster and release from the Booster at separation.

3.7.1.4.1 Payload Accommodations. The Orbiter shall provide the detail payload accommodations specified in IF255G700.

3.7.1.4.1.1 Cargo Bay Door. The cargo bay door shall be capable of opening to provide an 180-degree clear field of view for the payloads at the plane of the hinge line. The time required to open or close the door on-orbit shall not exceed five (5) minutes. During ground operations, the Orbiter shall be capable of opening the cargo door with surface winds up to 15 knots. The cargo door shall utilize assistance from GSE for operation when surface winds exceed 15 knots.

3.7.1.4.1.2 Payload Latches and Releases. Payload latches and releases shall be as specified in IF255G700.

3.7.1.4.1.3 Payload Deployment Mechanism. The payload deployment mechanism shall be capable of deploying the payload as specified in IF255G700.

3.7.1.4.1.4 Payload Release and Docking Mechanism. The payload release and docking mechanism shall release and retract payloads from the deployed position as specified in IF255G700.

3.7.1.4.2 Separation System. The Orbiter shall provide mating hard points and release mechanisms for Booster mating and release as specified in IF255G600.

3.7.1.4.2.1 Back-Up Release. The Orbiter shall incorporate back-up release devices to assure Orbiter release from the Booster in the event of Booster failure to achieve separation.

3.7.2 Propulsion Group. The Orbiter propulsion systems shall include a main propulsion subsystem, an attitude control propulsion subsystem, an orbit maneuver subsystem, an air-breathing propulsion subsystem and an auxiliary power subsystem.

3.7.2.1 Main Propulsion. The main propulsion subsystem shall provide boost and attitude control during the Orbiter-powered ascent phase. The main propulsion subsystem shall consist of propellant supply and control ancillary subsystems, and two GFE high pressure oxygen-hydrogen engines, as defined in 13M15000. The ancillary subsystems shall meet the requirements of propellant supply, tank pressurization, and vent/relief, propellant fill and drain, tank passivation, pneumatic control, propellant management engine childown, POGO suppression, thermal control, engine purge and instrumentation.

3.7.2.1.1 Main Engine. The main engine thrust levels and performance requirements are specified in Table IV. The Orbiter shall provide the clearance necessary to accommodate engine gimballing.

3.7.2.1.2 Main Engine Purge. Engine flight purges shall be accomplished in accordance with 13M15000.

3.7.2.1.3 Engine Chilldown. Circulation of propellants through the feedlines is required on the ground prior to engine start to condition the respective feed system and meet the required

TABLE IV MAIN ENGINE THRUST AND PERFORMANCE

Maximum Thrust Level	689,600	lbs
Normal Thrust Level	632,200	lbs
Minimum Thrust Level	316,100	lbs
Variation in mean thrust level	TBD	lbs
Oscillations about mean thrust level	TBD	lbs
Rate of change of thrust	TBD	lbs/sec
Thrust acceleration	TBD	lbs/sec^2
Engine Vacuum Specific Impulse		
@ Normal Power Level (nominal)	459	sec
@ Normal Power Level (minimum)	456	sec
Gimbal Angle (Pitch/Yaw)	$\pm 6°/\pm 3°$	

engine interface temperature condition. The propellant circulation rate shall be sufficient to maintain conditioned propellants at the engine inlet and to suppress propellant geysering.

3.7.2.1.4 Propellant Supply. The propellant supply system shall provide liquid oxygen (LOX) and liquid hydrogen (LH_2) at the conditions specified in 13M15000. Separate LOX and LH_2 feed systems shall control the transfer of propellants from their tanks to the main engines. The feedlines to the main engines shall include flexible bellows and shall be located to ensure sufficient freedom for misalignments due to tolerance buildup and structural deflections. The propellant lines shall have minimized heat leaks to assure meeting the engine inlet requirements. This low-pressure ducting shall be designed to withstand nominal operating surge pressures experienced during ground and flight operations and shall have provisions for a passive POGO suppression system. Propellants required for engine operations shall pass through propellant tank antivortex devices to suppress vortexing and provide filtration.

3.7.2.1.5 Pressurization. The LOX and LH_2 tank pressurization that satisfies the net positive suction head (NPSH) inlet requirements of the main engines shall be accomplished by pre-pressurization and in-flight pressurization. Provisions shall also be made for propellant tank venting. The respective diffusers shall be designed so that the velocity of the pressurizing gas entering each propellant tank shall not cause an unacceptable tank pressure collapse. The LOX and LH_2 tank pressure relief valves shall operate within the limits of 28 and 30 psia during ascent. The LOX and LH_2 vent and relief operating pressure limits shall be 17 to 19 psia during the reentry and flyback portion of the mission. Venting during the reentry portion, however, shall be minimized.

3.7.2.1.6 Prepressurization. The LOX and LH_2 prepressurization sequences shall be used for engine start, and shall use pressurized gaseous helium obtained from ground equipment.

3.7.2.1.7 Inflight Pressurization. Subsequent to main engine ignition, the LH_2 tank pressure shall be maintained with hydrogen gas supplied by a bleed system on the engine to ensure satisfactory main engine propellant pump inlet conditions. The LOX tank pressurization system shall be designed to utilize the main engine GOX bleed capability to meet the required pump inlet pressure conditions.

3.7.2.1.8 Venting. Venting provisions shall be provided to prevent rupture of the propellant tanks. During fill, the gaseous oxygen and hydrogen shall be vented through the tank vent. During flight, the gaseous oxygen and hydrogen will be vented overboard through non-propulsive vents. The effective vent area of each of these valves shall be such that tank ullage pressure shall not exceed the maximum allowable tank pressures. Vent paths employed during reentry and flyback will be located and functioned in such a manner as to minimize any hazardous effects.

3.7.2.1.9 Propellant Management. The stage shall include propellant loadings sensors in the LOX and LH_2 tanks which shall provide electrical signals during propellant loading when the propellant reaches the design propellant level. These signals shall provide three sigma loading accuracies to TBD percent for LOX and TBD percent for LH_2 at the design propellant level. In-flight propellant utilization shall be closed loop. Cut-off signals shall be provided by level sensors.

3.7.2.1.10 Propellant Fill And Drain. Separate propellant tank fill systems shall be provided to transfer fluids from the ground supply interface to the LOX and LH_2 tanks. Each system shall be capable of reverse flow for tank drainage. Loading and topping of each tank shall be accomplished through a single fill connection. The fill and drain system shall be capable of filling and draining the propellant tanks. The fill and drain operations shall be controlled through valves in the ground system.

3.7.2.1.11 Propellant Dump. Capability to deplete cryogenic residual propellants prior to landing shall be provided for normal missions.

3.7.2.1.12 Pneumatic. The pneumatic system supply shall consist of ambient helium gas stored in high pressure spheres. The stage shall provide the required engine pneumatics in accordance with 13M15000.

3.7.2.1.13 Thrust Vector Control (TVC). The thrust vector control system for gimballing the main engines shall be provided by hydraulic servo actuators supplied by power from the Orbiter hydraulic system. The actuators shall gimbal the main engines ±6 degrees in pitch and ±3 degrees in yaw. The actuators shall be designed for activation by multiple hydraulic system power sources.

3.7.2.2 Attitude Control Propulsion System (ACPS). The ACPS shall provide the required impulse for three axis angular control of the Orbiter utilizing gaseous hydrogen-gaseous oxygen engines. The system shall also provide three axis translation control of the Orbiter while in orbit.

3.7.2.2.1 ACPS Accelerations. The ACPS shall be capable of providing three axis attitude control torques and multiaxis vernier translation maneuver accelerations as follows:

	Minimum Requirement	
Maneuver	Operational	Emergency
Roll	90,000 Ft-lbs	30,000 Ft-lbs
Pitch	115,000 Ft-lbs	115,000 Ft-lbs
Yaw	235,000 Ft-lbs	115,000 Ft-lbs
Lateral	0.2 ft/sec^2	N/A
Vertical	0.2 ft/sec^2	N/A
Longitudinal	0.4 ft/sec^2	N/A

3.7.2.2.2 ACPS Impulse Propellant. Total impulse propellant capability of the ACPS shall be based on the following criteria.

Function	Propellant Criteria
Orbit Attitude Control	477,000 lb-sec
Reentry Attitude Control	720,000 lb-sec
Orbit Translation	185 ft/sec

3.7.2.2.3 ACPS Specific Impulse. The ACPS steady state system specific impulse shall be 379 seconds minimum and the pulsing mode system specific impulse shall be 362 second minimum.

3.7.2.2.4 ACPS Burn Durations. The maximum duration single burn shall not exceed TBD seconds and the minimum impulse bit shall be 50 lb-sec. The minimum duration from command initiation to 90 percent thrust level shall not exceed TBD seconds.

3.7.2.3 Airbreathing Engine System (ABES). The airbreathing engine system, utilizing JP type fuel, shall provide approach and landing abort go-around capability during operational missions and the required thrust for ferry flight performance. The system shall incorporate four (4) engines each providing a sea level thrust of 20,000 ± 1000 pounds.

3.7.2.3.1 Engine Starting. The airbreathing engines shall be capable of air-starting at an altitude of 40,000 ft following reentry and transition to subsonic glide flight. An engine starting system shall be provided to assist and assure engine start. Engine starting for ferry missions shall be accomplished by ground support equipment.

3.7.2.3.2 Engine Provisions. Inlet anti-icing and fire containment, detection and extinguishing capabilities shall be provided.

3.7.2.3.3 Engine Removal. The ABES shall be designed to be removable with minimum scar weight.

3.7.2.3.4 Ferry Flights Operation. The system shall be capable of operation to support the ferry flight performance specified in 3.2.1.2.9.

3.7.2.4 Orbit Maneuver System (OMS). The OMS,utilizing liquid hydrogen and liquid oxygen, shall provide the required impulse for all major orbit maneuvers including circularization, plane change, gross rendezvous and deorbit.

3.7.2.4.1 OMS Acceleration. The OMS shall be capable of providing a minimum Orbiter translation acceleration of .65 ft/sec^2 normally and TBD ft/sec^2 under emergency conditions.

3.7.2.4.2 OMS System Impulse Propellant. The impulse propellant capability of the OMS shall be equivalent to a ΔV of 1315 ft/sec nominal and a ΔV of 1815 ft/sec maximum capability.

3.7.2.4.3 OMS Specific Impulse. The OMS steady state system specific impulse shall be 444 second minimum.

3.7.2.4.4 OMS Burn Durations. The maximum duration single burn shall not exceed TBD second, and the shutdown total impulse tolerance shall not exceed TBD lb-secs.

3.7.2.4.5 OMS Propellant Supply. For the resupply reference mission, sufficient propellant tank capacity shall be supplied to provide 2000 feet per second on-orbit delta velocity capability in excess of the amount required to attain the designated insertion orbit. A portion of this delta velocity is multiaxis and shall be provided by the ACPS.

3.7.2.5 Auxiliary Power Unit Subsystem. The auxiliary power unit (APU) system shall provide the prime movers for separate circuits to supply hydraulic power for all Orbiter functions and electrical power for Orbiter main engine operation.

3.7.2.5.1 APU Power. The APU system shall be capable of delivering the following power:

Power	Peak	Mode	Idle
Hydraulic HP	277	TBD	10
Electrical, Pump and Gearbox	55	TBD	25
Total Shaft HP	332	TBD	35

3.7.2.5.2 APU Duty Cycle. The APU system shall be capable of providing approximately 350 Hp-Hrs of energy, the specific duty cycle as follows:

A. 72 sec at peak power level.

B. TBD sec at mode power level.

C. 4210 sec at idle power level.

3.7.2.5.3 Exhaust Product Venting. Ducting shall be provided to duct APU combustion products overboard to a ground vent during on-pad operation. APU combustion products shall be ducted overboard through non-propulsive vents during all flight phases.

3.7.3 Avionics Group. An integrated avionics group shall be provided which includes the functions of guidance and navigation, flight control, communications, on-board checkout, configuration and sequencing control, electronic displays, data management, and other functions which require computational capability or exchange of data between subsystems. Autopilot systems and navigation aids similar to systems used in commercial aircraft shall be included.

3.7.3.1 Guidance and Navigation. The guidance and navigation (G&N) system shall be designed to maintain knowledge of vehicle position, velocity, and attitude and shall compute steering signals, so that appropriate maneuvers can be performed to:

A. Inject the Orbiter into a specified orbit.

B. Transfer from one orbit to another to accomplish rendezvous or desired phasing for subsequent maneuvers.

C. Deorbit and return to a specified landing site.

D. Ferry from one geographical location to another at subsonic speeds.

E. Provide alternatives in the event aborts occur during normal operation.

The Orbiter G&N system shall be capable of satisfying the above performance from on-board equipment provided the following external data and interfacing equipment is provided:

A. Longitude, latitude and altitude of launch and landing sites.

B. Ephemeris position and velocity of rendezvous target.

C. RF transponding equipment aboard cooperative rendezvous targets.

D. Lights for night rendezvous and docking.

E. Areas navigation and landing aids located at or near the landing site.

F. Preflight equipment alignment and appropriate calibration.

G. Booster separation.

In addition, the capability to use Planned Manned Space Flight Network (MSFN) as an alternate source of orbital update information shall be provided. To provide the required guidance functions, the system shall solve the appropriate set of equations with the necessary input sensor and configuration data and the desired end conditions. Outputs of the guidance equations shall be vehicle steering commands to flight control and displays and thrust level commands to engines and displays.

3.7.3.1.1 Prelaunch Initialization. The capability to initialize the navigation system from on-board equipment and appropriate ground equipment shall be provided. Accuracy of initialization shall be consistent with that required to accomplish insertion accuracies specified in 3.7.3.1.3. Guidance and navigation system alignment shall allow an all azimuth launch capability.

3.7.3.1.2 Vehicle Attitude. The system shall provide yaw, pitch and roll attitude of the vehicle for display and guidance. For display, the yaw, pitch and roll data shall be accurate to within ± 0.5 degrees. For guidance, the accuracy shall be consistent with that required to satisfy injection, rendezvous, orbit, transfer, entry, landing and cruise. Unrestricted attitude capability shall be provided.

3.7.3.1.3 Orbit Insertion. For the design mission, the navigation system shall provide vehicle position and velocity data within the following three sigma accuracy at the insertion altitude of 50 nautical miles:

Parameter	Position	Velocity
Radial	4000 ft	25 ft/sec
Tangential	4000 ft	15 ft/sec
Normal	5000 ft	30 ft/sec

Guidance shall be provided for orbital insertion and subsequent transfer to the orbit reference trajectory, consistent with vehicle constraints. An all azimuth launch navigation and guidance capability shall be provided.

3.7.3.1.4 Orbit Transfer. On-board guidance and navigation shall be provided for orbit transfer.

3.7.3.1.5 Rendezvous. The guidance and navigation system shall compute maneuver times and steering commands needed to achieve rendezvous with targets as specified in 3.2.1.2.4.3. The information shall be computed on-board with only the knowledge of the present state of the orbit and the ephemeris of the target.

3.7.3.1.6 Stationkeeping. For cooperative targets, a controlled drift mode of stationkeeping shall be provided. This shall contain the Orbiter in an envelop bounded by a minimum trailing displacement of 500 feet for collision avoidance and a maximum trailing displacement of 30 nautical miles. Appropriate caution and warning shall be provied to alert the crew of an impending collision.

3.7.3.1.7 Docking. The requirements for docking are TBD.

3.7.3.1.8 Orbit Alignment. The capability to align the IMU sensor element to a known coordinate reference frame shall be provided. The alignment of the IMU shall be known with respect to an Earth reference within ±9 arc minutes, 3 sigma (all axes).

3.7.3.1.9 Orbit Navigation. The three sigma on-board navigation error contributions to the entry position at 100,000 feet altitude shall not exceed 9 miles cross-range, 9 miles down-range and 9 miles altitude.

3.7.3.1.10 Reentry and Landing. The navigation and guidance system shall provide reentry steering to limit vehicle entry temperatures and provide landing at a preselected landing site. Navigational aides at the landing site will be provided.

3.7.3.1.11 Abort. The requirements for abort are TBD.

3.7.3.1.12 Ferry. Guidance and navigation capability for ferry flights between landing sites shall be provided.

3.7.3.2 Flight Control Electronics. The flight control electronics system shall be designed to provide flight path control and maneuver execution by controlling and stabilizing vehicle attitudes through use of force producing elements. The subsystem shall provide the flight control capabilities specified in Table V.

TABLE V FLIGHT CONTROL CAPABILITIES

Mission Phase	Control Description
Ascent	Automatic rate command system using rate gyro feedback with attitude feedback through ascent steering equations.
On-Orbit (Attitude)	Manual Modes - Acceleration, pulse, rate command/attitude hold. Automatic Mode - Attitude hold.
On-Orbit (Translation)	Manual Modes - Acceleration. Automatic Mode - ΔV increment.
Entry	Manual Mode - Yaw (bank) and pitch rate command. Automatic Mode - Bank maneuver by yaw control, and in pitch, calculated angle-of-attack feedback to position elevons for trim.
Subsonic (Longitudinal Control)	Manual Mode - Pitch rate command with control augmentation. Autopilot Modes - ° manual flight path angle command ° altitude hold ° automatic angle-of-attack ° automatic approach and landing
Subsonic (Lateral Axis Control)	Manual Mode - Manual roll and yaw inputs with control augmentation. Autopilot Modes - ° manual bank command ° automatic landing (to touchdown) ° heading hold
Subsonic (Velocity Control)	Manual and automatic control of engine thrust and speed brake position.

3.7.3.3 Data Management. The data management system (DMS) shall perform: on-board computation; data acquisition and interface; and data storage.

3.7.3.3.1 On-Board Computation. The DMS shall provide on-board computation to: navigate, guide and control the vehicle; process data for subsystems, perform vehicle checkout and fault isolation; perform redundancy management; and perform mission planning.

3.7.3.3.1.1 Navigation, Guidance and Control Computations. The system shall supply the navigation, guidance and digital control computations for automatic and manual control of the vehicle. Vehicle flight control parameters, commands and desired trajectories shall be computed and displayed for both automatic and manual control by the crew.

3.7.3.3.1.2 Vehicle Checkout and Fault Isolation. The DMS shall provide the capability for in-flight vehicle checkout and fault isolation to allow switching to redundant units. The system shall also provide ground checkout capability to detect and isolate failures for vehicle maintenance. The data system shall provide self-validation and error protection.

3.7.3.3.1.3 Vehicle Configuration and Control. The system shall provide automatic vehicle configuration control including subsystem redundancy management, during all phases of flight.

Provisions shall also be provided for crew override and mode selection. The redundancy management function shall provide failure detection, isolation and switchover.

3.7.3.3.1.4 Mission Planning. The system shall perform a mission planning function during launch and while on-orbit by determining the planning required to allow execution of the next phase of flight.

3.7.3.3.2 Data Acquisition and Interface. This system shall provide data transfer implementation, control and remote data interfacing. Data buses shall be provided for Orbiter interfaces with the Booster, payload and GSE as specified in IF255G600, IF255G700 and IF255G800, respectively. The Orbiter/Booster interface shall transfer data on hazardous/emergency conditions from one stage to the other for simultaneous crew alert and for allowing separation initiation from either stage. The GSE interface shall allow test and operational data to be gathered during ground test without requiring an operator in the crew compartment of the Orbiter. The payload interface shall provide the capability for the Orbiter DMS to support the payload in checkout and in initialization of payload sequences.

The data management system shall also provide a data bus interface with the engine avionics to transfer thrust command, mixture ratio command, discrete sequence commands, and monitor engine status as specified in 13M15000.

3.7.3.3.3 Data Storage. The DMS shall provide storage for data, including the following:

A. A record of mission events and times for execution of events.

B. A record of preflight established procedures to assist the crew in carrying out the mission.

C. A record of selected data for ground maintenance of the vehicle.

Display capabilities for on-board ground maintenance procedures and applicable historical data gathered during the mission shall be provided.

3.7.3.4 Communications and Navaids.

3.7.3.4.1 Communications. The communications and navaids subsystem shall provide Orbiter intercom and RF communications with the Booster, payload, and ground equipment as specified, respectively in IF255G600, IF255G700 and IF255G800.

3.7.3.4.1.1 Intercom. The Orbiter intercom shall provide the following:

A. Two-way voice between the crew headsets.

B. Two-way voice between the crew station and the Orbiter airlock.

C. Two-way voice between the crew station and the payload module.

D. Two-way voice between the crew station and intercom taps for ground personnel.

E. Two-way voice between the crew station and the Booster crew station.

F. One-way voice from emergency oxygen masks to crew station.

G. One-way aural identification and voice from navaid equipment to the crew station.

3.7.3.4.1.2 RF Telecommunications. The system shall provide telecommunications between the Orbiter and other vehicles/equipment as specified in Table VI. Attitude restrictions to maintain Orbiter and the Earth or other elements shall be minimized. Continuous communications and tracking will not be required. Any antenna systems that require pointing for acquisition shall be pointed automatically without requiring a man in the loop except to initiate the command. Maintaining acquisition shall also be automatic.

TABLE VI ORBITER TELECOMMUNICATIONS SUBSYSTEM CAPABILITY

	Slant Range - Max (Limited By L.O.S.)	Modes	Rates	Accuracy
Between Orbiter and MSFN	1800 N.M. (Assumes MSFN-30 ft dish)	Two-way voice (full duplex)	300-3000 Hz	98% Sentence Intelligibility
		Two-way data (full duplex)	Down: 10 KBPS UP: 1 KBPS	10^{-5} Bit Error Rate
		Ranging Transponder	-----	-------
Between Orbiter and Booster	1 N.M.	Two-way voice (Half duplex)	300-3000 Hz	98% Sentence Intelligibility
Between Orbiter and Airport	175 N.M.*	Two-way voice (half duplex)	300-3000 Hz	98% Sentence Intelligibility
Between Orbiter and Space Station	250 N.M.**	Two-way voice (full duplex)	300-3000 Hz	98% Sentence Intelligibility
		Two-way data (full duplex)	1 KBPS (each way)	10^{-5} Bit Error Rate
Between Orbiter and EVA	1 N.M.	Two-way voice (full duplex)	300-3000 Hz	98% Sentence Intelligibility
		One-way data (EVA to Orbiter)	1 KBPS (each way)	10^{-5} Bit Error Rate
Between Orbiter and Free Flying Payload	1 N.M.	Two-way voice (half duplex)	300-3000 Hz	98% Sentence Intelligibility
		Two-way data (full duplex)	1 KBPS (each way)	10^{-5} Bit Error Rate

NOTES:

*Standard Airport Equipment Assumed
**Space Station Equipment Equivalent to Orbiter Equipment Assumed

3.7.3.4.2 Navaids. The navaids shall provide on-board position updating after reentry to allow the Orbiter to maneuver to the desired landing site. The navaids shall also facilitate enroute navigation during ferry flight.

During approach and landing, the navaids shall provide data to be used in deriving azimuth, elevation, range to touchdown, and vertical guidance signals which are required for an automatic landing capability. The navaid equipment shall furnish raw measurement data including:

A. Direct distance and bearing angle to ground stations,
B. Altitude above the terrain.
C. Vertical and lateral deviations from a nominal flight path.

The navaids shall provide the ranges, modes, and accuracies specified in Table VII.

3.7.3.5 Crew Station Controls and Displays. The crew station controls and displays system shall provide the two man crew with the capability of monitoring and controlling the on-board operational subsystems of the Orbiter. The two crewmen shall be positioned in a side-to-side arrangement and the displays and controls shall be duplicated where necessary to allow vehicle emergency operational control from either crew position. The crew station equipment complement, operated and monitored by the crew, shall satisfy the manned mission functional requirements of:

TABLE VII ORBITER RF NAVAIDS SUBSYSTEM CAPABILITY

	Between Orbiter & Space Sta. (LOS)*	Aerocruise Mode (LOS)	Landing Mode (Ground Range)
Ranges	400 N.M.	200 N.M.	50,000 ft (7,000 ft altitude)
Modes	Ranging	Range to known ground station Bearing to known ground station	Altitude measure below 2500 ft altitude. Measure slant range to touch-down. Approach path determination
Accuracy Subsystem Including Ground Equipment	± .3% of range or 100 ft whichever is greater (3σ)	Range: (3σ) ±4500 ft Bearing: (3σ) ±2.5°	Altitude - (3σ) ±2 ft or ±2% (500 ft altitude to touchdown) ±3.0% of altitude (2,500 ft to 500 ft) Range - (3σ) ±500 ft from range of 10,000 ft to touchdown ±600 ft from range of 50,000 ft to 10,000 ft Elevation - (3σ) ±.2° or ±9 ft whichever is greater for range of 20,000 ft to the threshold Azimuth - (3σ) ±.4° 50,000 ft to 27,000 ft range decreasing linearly to ±0.1° at range of 3,500 ft from touchdown, ±15 ft from 3,500 ft to touchdown

*LOS - Line of Sight

A. Vehicle Flight Control and Display

B. Subsystems Monitor and Control

C. Mission Monitor and Control

D. Special Interfaces Monitor and Control

The capability shall be provided for crew interrupt/override of any automated critical control function.

3.7.3.5.1 Vehicle Flight Control and Display. The controls and displays for vehicle flight control shall provide the following:

A. Ascent - Displays shall provide crew capability to monitor vehicle performance. Controls shall provide crew capability to initiate abort during the automatic ascent guidance and control period.

B. On-Orbit - Pilot displays and hand controller devices shall be provided for manual control of on-orbit attitude and translational maneuvers. These devices shall be complemented by mode select and computer terminal controls and displays to provide crew initiation and monitor capability for automatic control of on-orbit attitude and translation maneuvers, orbit transfer (ΔV) maneuvers, and stationkeeping maneuvers.

C. Reentry and Landing - The system shall include provisions to allow crew initiation and monitoring of automatic reentry and landing attitude and velocity control. The capability shall be provided for crew takeover of control at any point in this flight profile.

3.7.3.5.2 Subsystem Controls and Displays. Subsystem controls and displays shall provide manual mode selection with computer automated subsequencing to reduce the crew workload.

Subsystem panels for configuration/mode control and performance/status monitoring shall be integrated on a subsystem/function basis and shall be positioned on a crew utilization rate basis to reduce the crew workload.

All displays and controls associated with enabling the crew to recognize and correct critical systems malfunctions shall be functionally independent of ground support and external interfaces.

Flexible page/pad format displays shall be provided for crew/computer communications to ease the crew workload and increase operational confidence.

3.7.3.5.3 Mission Control and Monitor. The on-board data management system in concert with the crew station equipment shall provide the display of preflight established procedures and data to assist the crewmen in executing the basic autonomous mission plan. The same equipment complement shall provide the crew with the capability for in-flight vehicle checkout and for determining and executing contingency mission plans.

3.7.3.5.4 Special Interfaces Monitor and Control. The crew station controls and displays shall provide Orbiter status monitoring and control of Booster and payload functions as specified respectively in IF255G600 and IF255G700.

3.7.3.6 On-Board Checkout. On-board checkout capability shall be provided for autonomous in-flight operations and a significant on-board capability shall be provided for ground operations. The on-board function shall utilize the central computational capability and the data management subsystem to acquire, evaluate and display checkout related parameters. The primary method of equipment evaluation shall be comparison of redundant subsystems data and built-in test (BIT). Checkout of all on-board systems shall employ an end-to-end test scheme with the minimum of health parameter monitoring. On-board checkout shall provide a capability to be augmented by GSE on a selective basis.

3.7.3.7 Orbiter Flight Software. The detail requirements for software are defined in TBD.

3.7.4 Crew Station Group. The general arrangement of the crew station shall be as shown in Figure 9. The crew station shall be designed to accommodate a two-man flight crew and two cargo handlers of 5 to 95 percentile.

3.7.4.1 Environmental Control and Life Support (ECLS). The ECLS shall provide the Orbiter crew station with a shirtsleeve environment, a water management subsystem, a waste management subsystem and equipment thermal control throughout the Orbiter mission.

The Orbiter shall be designed to utilize Ground Support Equipment (GSE) for ECLS functions during prelaunch and launch.

3.7.4.1.1 Shirtsleeve Environment. The crew station environmental control shall be as follows:

A. Atmosphere - The atmosphere shall consist of nitrogen and oxygen with an oxygen nominal partial pressure of 3.1 ± TBD psia from 10.7 psia to 14.7 psia total pressure. Atmosphere circulation shall provide cooling and prevent concentration of carbon dioxide and water vapor.

B. Temperature - The crew compartment atmospheric temperature shall be controlled to 70°F ± 5° except during entry when the air shall not exceed 100°F.

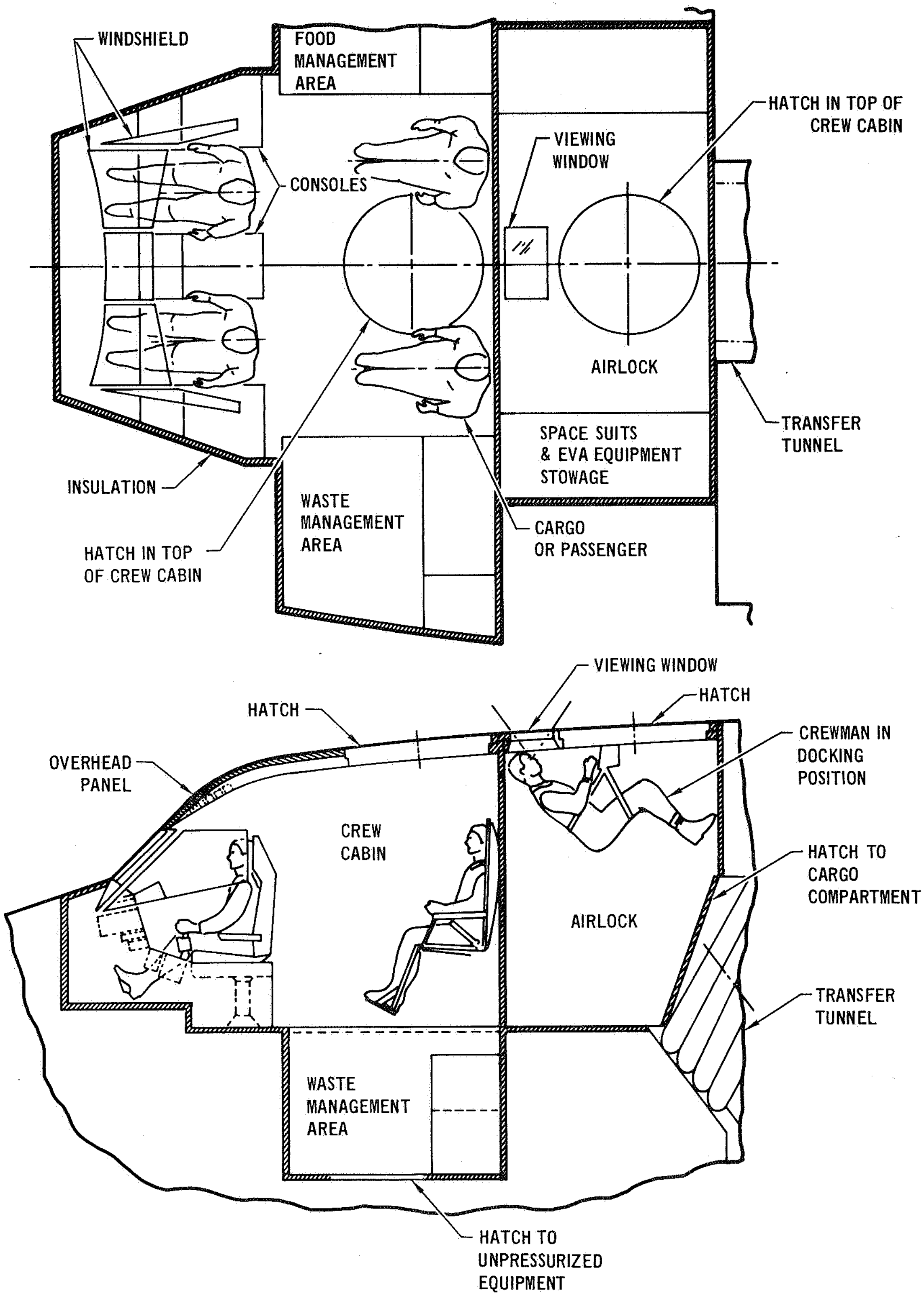


FIGURE 9 CREW STATION ARRANGEMENT

C. Pressure - Cabin pressure shall be adjustable prior to launch to 10 or 14.7 psia with an accuracy of TBD psia. Vents shall be provided to maintain the desired pressure during ascent and entry and to allow cabin pressure relief for emergency atmospheric dump.

D. Humidity - The minimum dewpoint shall not be less than 46°F. The maximum dewpoint shall not result in visable condensation on cabin walls and surfaces.

For emergency conditions, to extinguish fire, the system shall be capable of flooding the compartment with nitrogen. Oxygen masks shall be provided for the crew and cargo handlers during this operation.

3.7.4.1.2 Water Management. TBD pounds of drinking water shall be provided per day during each mission.

Provisions shall be incorporated for overboard dumping of excess product and condensate water collected.

3.7.4.1.3 Atmosphere Gas Supply. Gas supplies shall be sized for a crew compartment leakage rate of TBD pounds per day in orbit. Metabolic oxygen shall be provided to supply two pounds per man per day. Additional oxygen and nitrogen shall be available for one crew compartment repressurization at a rate of TBD $\pm$ TBD pounds per minute.

An emergency 48 hour oxygen supply shall be provided in addition to the above.

3.7.4.1.4 Atmosphere Revitalization. Carbon dioxide control of the crew compartment atmosphere shall be provided. During normal operations, the compartment carbon dioxide partial pressure shall not exceed 5.0 MM Hg.

3.7.4.1.5 Waste Management. The waste management system shall be designed for both male and female crew personnel. Feces and urine collection and storage equipment shall be provided. An overboard dump capability for urine shall be provided.

3.7.4.1.6 Equipment Thermal Control. The system shall provide thermal control for temperature sensitive equipment during all mission phases after liftoff.

The system shall be designed to utilize GSE supplied temperature control during the prelaunch and launch phases.

3.7.4.1.7 ECLS Controls and Displays. ECLS controls and displays shall be provided to actuate, adjust and monitor subsystem performance throughout the mission. Parameters that are vital to subsystem operation shall be available for display of caution and warning.

3.7.4.2 Crew Systems. The crew systems shall provide systems required by the flight crew and passengers in their performance of mission operations. These systems include crew station furnishings and equipment, instrument panels, consoles, subsystem displays and controls and flight control equipment.

3.7.4.2.1 Crew Seats. Unitized crew seats shall be incorporated to provide maximum crew comfort. Seat belts and shoulder straps shall be retractable for ease of stowage in zero gravity.

3.7.4.2.2 Cargo Handler Supports. Cargo handler supports shall be designed for optimum comfort and position for launch, zero gravity and reentry loads.

3.7.4.2.3 Mobility Aids. Mobility aids shall be incorporated throughout all crew areas for on-pad, zero gravity, and horizontal flight conditions.

3.7.4.2.4 Personal Stowage Facilities. Personal stowage facilities shall be provided for the crew and the cargo handlers.

3.7.4.2.5 Food Handling. Provisions for food preparation, heating, refrigeration, and storage shall be provided.

3.7.4.2.6 Hygiene. A privacy area shall be provided for personal hygiene.

3.7.4.2.7 Instrument Panels, Consoles, Controls and Displays.

The crew compartment controls and displays shall be provided on the following panels: the main instrument panel; the left outboard console; the right outboard console; the center console; and the overhead panel. The side-by-side crew arrangement shall place piloting functions on the left-hand side and engineer and navigation functions on the right-hand side. Functions common to both shall be located in the center area of the main panel, the center console, and in the overhead panel.

3.7.4.2.7.1 Main Instrument Panel. The instruments necessary to monitor the flight parameters for all phases of the mission shall be in the primary scan and reach area of each crewman. Access to the time reference systems and computer input/output devices shall be provided for each crewman for effective systems management.

Displays and controls for ECLS, propulsion, electrical power and hydraulics systems shall be provided within the scan and reach area of both crewman in the center area of the instrument panel.

Landing gear controls and surface position indicators shall also be located in this area in accordance with general airplane design practice.

3.7.4.2.7.2 Outboard Consoles. Each outboard console shall contain:

A. Vent, seat, and lighting controls.

B. Orbit attitude controllers and their associated mode selections.

C. Communication system selection and control.

The left console for the command pilot shall also include:

A. The abort control.

B. The drag chute control.

The right console shall include the necessary payload deployment controls and the ECLS gas supply controls.

3.7.4.2.7.3 Center Console. Provisions on this console shall enable either crewman to perform

A. Selected avionics management (communications, navigation aids, and data management).

B. Propulsion systems management (cruise, orbit, and boost propulsion).

C. Orbital and cruise flight controls such as orbit attitude mode selection, flap controls, speed brake controls and trim controls.

3.7.4.2.7.4 Overhead Panel. The overhead panel shall be within the reach and vision area of both pilots and shall contain:

A. Fire warning and extinguisher controls.
B. Caution and warning functions.
C. Circuit protection.
D. Selected subsystem controls.

3.7.4.2.7.5 Malfunction Detection. A minimum of two methods of malfunction detection shall be provided for malfunctions affecting mission success requiring crew decision and action. These may be in the form of displays or physiological sensing.

3.7.4.2.8 Flight Control Equipment.

3.7.4.2.8.1 Aerodynamic Flight Controls. The side-by-side cockpit arrangement shall contain conventional control sticks for pitch and roll and rudder pedals for yaw control in the aerodynamic flight regime. Control stick and rudder pedal configuration and operation shall be consistent with current aircraft practices.

Conventional aircraft type controls shall be provided for operating speed brakes and body flap.

3.7.4.2.8.2 Orbital Flight Controls. A three-axis attitude controller shall be provided at each crew station for attitude control during orbital flight. The controllers shall be similar in operation to those used in previous manned space vehicles. A three-axis translation hand controller shall also be provided for each crewman.

3.7.4.3 Windows. Visibility from the cockpit during landing shall be comparable to that of high-performance aircraft.

3.7.5 Power Group.

3.7.5.1 Electrical Power Subsystem. The electrical power subsystem shall generate, control, condition and distribute electrical power to the using loads within the vehicle.

3.7.5.1.1 DC Power. DC electrical power shall be provided to using loads at a nominal 120 VDC. DC electrical power shall be provided by TBD H_2O_2 fuel cell modules. Any batteries provided for use in contingency situations shall not require preconditioning prior to accepting loads.

3.7.5.1.2 AC Power. AC electrical power shall be generated at 120V/208V 3Ø 400 Hz. AC electrical power shall be distributed to the main propulsion engines at a nominal 115/200V and 400 Hz.

3.7.5.1.3 Power Quality. The electrical power subsystem shall provide power to the using loads that meets the quality requirements of TBD.

3.7.5.1.4 Loads. Each fuel cell module shall be capable of providing TBD KW to the using loads, including the main propulsion engines DC power specified in 13M15000. Each AC generator shall be capable of providing the main propulsion engine AC power specified in 13M15000. In addition, the electrical power subsystem shall supply power to the payload as specified in IF255G700.

3.7.5.1.5 Design Requirements. The electrical power subsystem shall be designed in accordance with the following requirements:

A. Four separate DC distribution channels shall be provided. Each fuel cell module shall be capable of satisfying the total Orbiter DC power requirements.

B. Three separate AC power distribution channels shall be provided to each main propulsion engine. Each AC generator shall be capable of satisfying the total main propulsion subsystem AC power requirements.

C. The capability shall be provided for paralleling two or more DC distribution channels on a single fuel cell module.

D. The electrical power control system shall be designed to prevent parallel operation of the AC generators.

E. Power distribution units shall be provided in the major load centers to control power to the loads and to provide circuit protection.

F. Remote power controllers shall be used to provide control and protection.

3.7.5.2 Hydraulic Power Subsystem (HPS). The HPS shall provide four (4) separate circuits operating at a nominal pressure of 3000 psig. The system shall be capable of generating, controlling and distributing the hydraulic power required for operation of main engine services, aerodynamic flight controls, and utility services such as landing gear, steering mechanisms, brakes, and ABES deployment.

3.7.5.2.1 Hydraulic Power. Each of the four hydraulic systems shall be designed to provide 277 $\pm$ TBD HP.

3.7.5.2.2 Hydraulic Fluids. The hydraulic system shall be designed to use fluids meeting the requirements of TBD.

4. VERIFICATION. Orbiter compliance with performance and design requirements specified in Section 3 shall be verified by assessment or test as specified in Table VIII.

4.1 Verification by Assessment. Assessments shall be accomplished by the following methods:

A. Inspections - Inspection shall be accomplished by reviewing drawings or the hardware itself for compliance with requirements such as construction features, workmanship, and dimensional requirements.

B. Analysis - Analysis shall be accomplished utilizing analytical techniques (systems engineering analysis, statistics, modeling) in lieu of or to supplement test data to verify such requirements as reentry performance, maintainability, useful life, and reliability.

C. Similarity - Qualification by similarity shall be accomplished by providing adequate substantiation that the article is similar or identical to an article previously qualified to equivalent or more stringent criteria.

D. Demonstration - Demonstration shall be accomplished by actual performance of a function to verify features such as: service and access, transportability, or human engineering features.

4.2 Verification by Test. When an adequate level of confidence cannot be established by assessment methods, testing shall be utilized for verification of requirements. Testing may also be accomplished where performance of the test is the simplest or most economical approach. Data from the following types of tests shall be utilized for verification by test:

A. Development tests - Development tests are used to verify the feasibility of the design approach and provide confidence in the ability of the hardware to pass qualification tests. Only those development tests used for verification shall be identified in the prime item specification.

B. Verification tests - Verification tests shall be performed as required to provide engineering information as needed to verify prime item compliance with performance and design requirements. Qualification tests shall be included under verification tests.

C. Acceptance tests - Acceptance tests shall be performed on all deliverable prime items to ensure that the item, as produced by production methods and quality control procedures, meets designated specification requirement and test requirements. Qualification test articles shall also pass acceptance tests prior to starting qualification tests. Acceptance testing shall be performed as an integral part of the quality assurance efforts. Final acceptance testing shall be performed at the highest level of assembly possible to ensure that all systems function properly. Alternate and redundant modes of operation shall be verified.

D. Launch site tests - Launch site tests shall be performed to ensure flight readiness of airborne and ground systems prior to launch. These include developmental and operational first flights of vehicles, and recurring flights and the resulting turn-around cycle of post-landing operations through prelaunch. Test capability, GSE, and procedures shall be similar, and in most cases, identical, to that of subsystem and combined systems tests performed at the factory.

4.3 Tests. Tests will be as defined in the Test Plan (Program Acquisition Plan, MDC E0308 Part III-5).

4.3.1 Development Tests. Test data from the following development tests shall be utilized for specification verification as specified in Table VIII.

(TBD)

4.3.2 Verification Tests. Test data from the following verification tests shall be utilized for specification verification as specified in Table VIII.

(TBD)

4.3.3 Acceptance Tests. Test data from the following acceptance tests shall be utilized for specification verification as specified in Table VIII.

(TBD)

4.3.4 Launch Site.Tests. The following launch site tests shall be utilized for specification verification as specified in Table VIII.

(TBD)

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3	X			
3.1	X			
3.1.1	X			
3.1.1.1	X			
3.1.1.2	X			
3.1.2	X			
3.1.3	X			
3.1.4	X			
3.2	X			
3.2.1	X			
3.2.1.1	X			
3.2.1.1.1	X			
3.2.1.1.2	X			
3.2.1.1.3	X			
3.2.1.1.4		b		
3.2.1.1.5		b		
3.2.1.2	X			

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.2.1.2.1	X			
3.2.1.2.1.1		a b		
3.2.1.2.2		b	c	7.3
3.2.1.2.2.1		b		
3.2.1.2.2.2		b		
3.2.1.2.2.3		b		
3.2.1.2.2.4		b		
3.2.1.2.2.5		b		
3.2.1.2.3	X			
3.2.1.2.3.1		b		
3.2.1.2.3.2	X			
3.2.1.2.3.3			a b	4.1, 7.2
3.2.1.2.3.4		b		
3.2.1.2.3.5		b	a	5.2.1
3.2.1.2.4	X			
3.2.1.2.4.1		b		
3.2.1.2.4.2		b	a b	5.4.2, 7.2
3.2.1.2.4.3		b		

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY

2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.2.1.2.4.4		b	b	7.2
3.2.1.2.4.5		b		
3.2.1.2.4.6		b		
3.2.1.2.5		b	b	6.2
3.2.1.2.5.1		b	a	4.1
3.2.1.2.5.2		b		
3.2.1.2.6	X			
3.2.1.2.6.1		b	a b	4.1, 4.2, 4.3
3.2.1.2.6.2		b	a b	4.1, 4.2, 4.3
3.2.1.2.6.3		b	b	5.2.1
3.2.1.2.6.4		b		
3.2.1.2.7	X			
3.2.1.2.7.1		a	b	7.2
3.2.1.2.7.2		b	b	7.4, 7.5
3.2.1.2.8		b		
3.2.1.2.9		b	b	7.4, 7.5
3.2.2	X			
3.2.2.1		b	c	7.3

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.2.2.2		a		
3.2.3	X			
3.2.3.1		b		
3.2.3.2		b		
3.2.4		b	b	7.0
3.2.5	X			
3.2.5.1		b		
3.2.5.2		b	b	5.0, Vol. I 4.0
3.2.6		a b		
3.2.7		b		
3.3	X			
3.3.1		b c	a	5.1.3
3.3.1.1		a b		
3.3.1.2		b c	b	5.0, Vol. I 4.0
3.3.1.3	X			
3.3.1.3.1		b		
3.3.1.3.2		a b		
3.3.1.3.3		a b		

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.3.1.4		b c	b	5.2.1, 5.2.2, 5.2.3, 5.2.4 5.2.5
3.3.1.5		a		
3.3.2		b	b	6.1, Vol. I 4.0, 6.2
3.3.3		a		
3.3.4		a	b	Vol. I 7.0
3.3.5		a	b	Vol. I 7.0
3.3.6	X			
3.3.6.1		b		
3.3.6.2		b	b	6.1, 6.3
3.3.6.3		b	c	5.3.5
3.3.6.4		b	b	5.2.1, 6.4
3.3.6.5		b		
3.3.6.6		b	b	7.5
3.3.7		b		
3.4	X			
3.5	X			
3.6	X			
3.7	X			

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD N/A	VERIFICATION METHOD 1	VERIFICATION METHOD 2	TEST PLAN PARAGRAPH
3.7.1		b	a b	5.1, 5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.5, Vol. I 5.2, 5.3
3.7.1.1		b		
3.7.1.2		b	a b c	5.1.6, 5.1.7, 7.4, 7.5
3.7.1.2.1		b		
3.7.1.2.2			a b c	7.4, 7.5
3.7.1.2.3			a b c	7.4, 7.5
3.7.1.2.4			a b c	6.3, 7.2
3.7.1.3		b c	a	5.1.3, 5.1.5
3.7.1.4	X			
3.7.1.4.1		a	a b	6.3, 7.2
3.7.1.4.1.1		a b	a b	6.3, 7.2
3.7.1.4.1.2		a	b	7.2
3.7.1.4.1.3		b	a b	5.1.6, 5.1.7
3.7.1.4.1.4		b	a b	5.1.6, 5.1.7, 7.2
3.7.1.4.2		a b	b	Vol. I 5.3
3.7.1.4.2.1		a b	b	Vol. I 5.3
3.7.2	X			

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.7.2.1		b		
3.7.2.1.1			b	5.2.1, 6.3, 6.4
3.7.2.1.2		b	b	5.2.1, 6.4
3.7.2.1.3		b	b	5.2.1, 6.4
3.7.2.1.4		b	b	5.2.1, 6.4
3.7.2.1.5		b	b	5.2.1, 6.4
3.7.2.1.6		b	b	5.2.1, 6.4
3.7.2.1.7		b	b	5.2.1, 6.4
3.7.2.1.8		b	b	5.2.1, 6.4
3.7.2.1.9		a b	b	5.2.1, 6.4
3.7.2.1.10		b	b	5.2.1, 6.4
3.7.2.1.11		b	b	5.2.1, 6.4
3.7.2.1.12		a b	b	5.2.1, 6.4
3.7.2.1.13			b	5.2.1, 6.3, 6.4
3.7.2.2		b		
3.7.2.2.1		b	b	5.2.2, 6.4
3.7.2.2.2		b		
3.7.2.2.3		b		

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.7.2.2.4		b	b	5.2.2
3.7.2.3		b		
3.7.2.3.1		b	a b	5.2.3, 7.4
3.7.2.3.2		b	a b	5.2.3, 7.4
3.7.2.3.3		b		
3.7.2.3.4			b	7.4
3.7.2.4		b		
3.7.2.4.1		b	b	5.2.5
3.7.2.4.2		b		
3.7.2.4.3		b		
3.7.2.4.4		b	b	5.2.5
3.7.2.4.5		b		
3.7.2.5	X			
3.7.2.5.1			b	Vol. I 4.0
3.7.2.5.2			b	Vol. I 4.0
3.7.2.5.3		b	b	Vol. I 4.0
3.7.3	X			
3.7.3.1		b		

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.7.3.1.1		b	a b	5.3.2, 5.3.7, 6.1, 7.2
3.7.3.1.2		b	a b	5.3.2, 5.3.7, 6.1, 7.2
3.7.3.1.3		b	a b	5.3.2, 5.3.7, 6.1
3.7.3.1.4		b		
3.7.3.1.5		b	a b	5.3.2, 5.3.7, 6.1
3.7.3.1.6		b	a b	5.3.2, 5.3.7, 6.1
3.7.3.1.7	X			
3.7.3.1.8		b	a b	5.3.2, 5.3.7, 6.1
3.7.3.1.9		b	a b	5.3.2, 5.3.7, 6.1
3.7.3.1.10		b	a b	4.2, 5.3.2, 5.3.7, 6.1
3.7.3.1.11	X			
3.7.3.1.12		b	b	5.3.2, 6.1, 6.3, 7.2
3.7.3.2		b	b	5.2.2, 5.3.4, 5.3.7, 6.1, 6.3, 7.2
3.7.3.3		b	a b	5.3.5, 5.3.7, 6.1
3.7.3.3.1		b	a b	5.3.5, 5.3.7, 6.1
3.7.3.3.1.1		b	a b	5.3.5, 5.3.7, 6.1
3.7.3.3.1.2		b	a b	5.3.5, 5.3.7, 6.1

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.7.3.3.1.3		b	a b	5.3.5, 5.3.7, 6.1
3.7.3.3.1.4		b	a b	5.3.5, 5.3.7, 6.1
3.7.3.3.2		b	a b	5.3.5, 5.3.7, 6.1
3.7.3.3.3		b	a b	5.3.5, 5.3.7, 6.1
3.7.3.4	X			
3.7.3.4.1		b	b	5.3.3, 7.1
3.7.3.4.1.1			b	5.3.3, 6.1
3.7.3.4.1.2		b	b	5.3.3, 6.1
3.7.3.4.2		b	b	5.3.3, 6.1
3.7.3.5		a b	a b	5.3.6, 5.3.7, 5.4.2, 6.1
3.7.3.5.1		a b	a b	5.3.6, 5.3.7, 5.4.2, 6.1
3.7.3.5.2		b	a b	5.3.6, 5.3.7, 5.4.2, 6.1
3.7.3.5.3		b	a b	5.3.6, 5.3.7, 5.4.2, 6.1
3.7.3.5.4		b	a b	5.3.6, 5.3.7, 5.4.2, 6.1
3.7.3.6		b	b	5.4.2, 7.3, 7.5, Vol. I 6.4, 6.5
3.7.3.7	X			
3.7.4		b		

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD N/A	VERIFICATION METHOD 1	VERIFICATION METHOD 2	TEST PLAN PARAGRAPH
3.7.4.1		b	b	5.4, 5.4.1, 5.4.2
3.7.4.1.1		b	b	5.4, 5.4.1, 5.4.2
3.7.4.1.2		b	b	5.4, 5.4.1, 5.4.2
3.7.4.1.3		b		
3.7.4.1.4		b	b	5.4, 5.4.1
3.7.4.1.5		b		
3.7.4.1.6		b	b	5.4.1, 7.2
3.7.4.1.7			b	5.4, 5.4.2, 7.2
3.7.4.2	X			
3.7.4.2.1		a		
3.7.4.2.2		a		
3.7.4.2.3		a	b	5.4.2
3.7.4.2.4		a		
3.7.4.2.5		a		
3.7.4.2.6		a		
3.7.4.2.7		a		
3.7.4.2.7.1		a		
3.7.4.2.7.2		a		

TABLE VIII VERIFICATION REQUIREMENTS MATRIX

VERIFICATION METHOD:

1. ASSESSMENT
   a. INSPECTION
   b. ANALYSIS
   c. SIMILARITY
2. TEST
   a. DEVELOPMENT
   b. VERIFICATION
   c. ACCEPTANCE

SECTION 3.0 PERFORMANCE/DESIGN REQUIREMENT REFERENCE	VERIFICATION METHOD			TEST PLAN PARAGRAPH
	N/A	1	2	
3.7.4.2.7.3		a		
3.7.4.2.7.4		a		
3.7.4.2.7.5		a b	b	6.1
3.7.4.2.8	X			
3.7.4.2.8.1		a		
3.7.4.2.8.2		a		
3.7.4.3		a		
3.7.5	X			
3.7.5.1		b	b	5.5.1
3.7.5.1.1		a b	b	5.5.1
3.7.5.1.2			b	5.5.1
3.7.5.1.3			b	5.5.1
3.7.5.1.4		b	b	5.5.1
3.7.5.1.5		a b	b	5.5.1
3.7.5.2		a b	b	5.5.2
3.7.5.2.1			b	5.5.2
3.7.5.2.2		b		

5. PREPARATION FOR DELIVERY. N/A

6. NOTES